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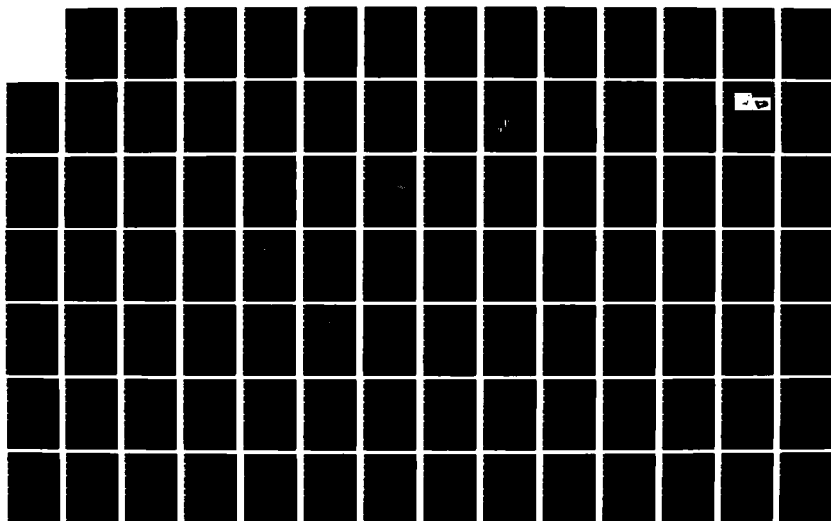
EDECT: AN ENERGY DESIGN EVALUATION AND COMPARISON TOOL
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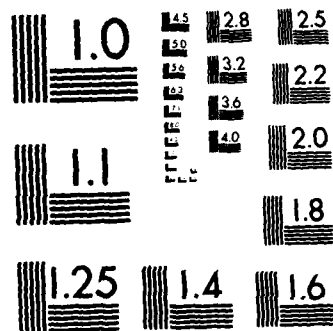
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THESIS ABSTRACT

**THE OHIO STATE UNIVERSITY
GRADUATE SCHOOL**

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QUARTER/YEAR: Spring, 1986

DEPARTMENT: Architecture

DEGREE: Master of Architecture

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**TITLE OF THESIS: EDECT: An Energy Design, Evaluation, and
Comparison Tool.**

EDECT is a computer-aided architectural design system which assists the architectural designer to accurately and rapidly determine the energy impact of his or her design decisions. The system emphasizes interactive computer graphic techniques and easily digested analysis results.

The basic 3D building model used by EDECT is generated on the ARCHIMODOS (Architectural Modeling, Design and Drafting System of the Ohio State University) system and read into EDECT memory at the beginning of a design session. EDECT culls ARCHIMODOS opening (window/door) data into its own data structure and enables user manipulation of the building components/aspects which most affect energy performance. These components/aspects include orientation, windows/dccrs, overhangs, and material selections. For a yearly energy analysis the user can define macroclimate, building type, mechanical and electrical systems, and number of occupants. EDECT's energy analysis is based on the American Institute of Architects' Simplified Energy Evaluation technique and yields numerical and graphical results. The user may also request EDECT evaluation of certain energy design aspects as well as elaboration on what the evaluation means.

EDECT is a 10,000 line FORTRAN IV program using GSP which runs on an IBM 4341 processor. Graphic interaction is primarily through an IBM 3251 vector refresh terminal with attached light pen.


Advisor's Signature

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EDECT: An Energy Design, Evaluation, and Comparison Tool

by

W. David Alley,
Captain, U.S.A.F.

1986

146 Pages

Master of Architecture - The Ohio State University.

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**EDECT:
AN ENERGY DESIGN, EVALUATION, AND COMPARISON TOOL**

A Thesis

**Presented in Partial Fulfillment of the Requirements for
the degree Master of Architecture in the
Graduate School of the Ohio State University**

**by
W. David Alley, B.S.**

*** * * * ***

**The Ohio State University
1986**


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**Advisor
School of Architecture**

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1986

In Memory Of My Grandfather, Lewis Moroni Dayton

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This thesis would have been impossible without the help of some very special people.

I thank Dr. Chris Yessios for his leadership in CAAD and for allowing me to be his pupil. Thanks go to the other members of my thesis committee, Dean Neuwenswander and Ken Lee, for their time and valuable comments.

I am indebted to my parents for their love, example and support of all kinds. I am grateful for the love and confidence of my dear sister, Lynette, and her family, and I thank Michael French for his unwavering friendship.

To my children, Julie Jeanne, John Harold and Lewis Michael, I thank you for cheerfully understanding why I spent so much time at school. And most importantly to my wife, Eva, I give my eternal thanks for your sacrifice and willingness to endure these last three years with me. This thesis belongs to us both.

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1. Introduction

Energy conservation in architecture is not as in vogue today as it was a decade ago. More often than not architectural schools as well as practices discuss energy conscious design only if forced to. Despite this lack of attention the energy issue has not gone away. Even neglecting possible limited or worldwide energy crises, the United States, with 6 percent of the world's population and 20 percent of the world's fossil fuel reserves accounts for 32 percent of the world's energy consumption (11). And our break-neck use of all types of energy is increasing rather than decreasing (24). The McKetta report, written in 1978, predicted ever increasing U.S. dependency on imported energy, (Figure 1) and within reason has been accurate for the last eight years.

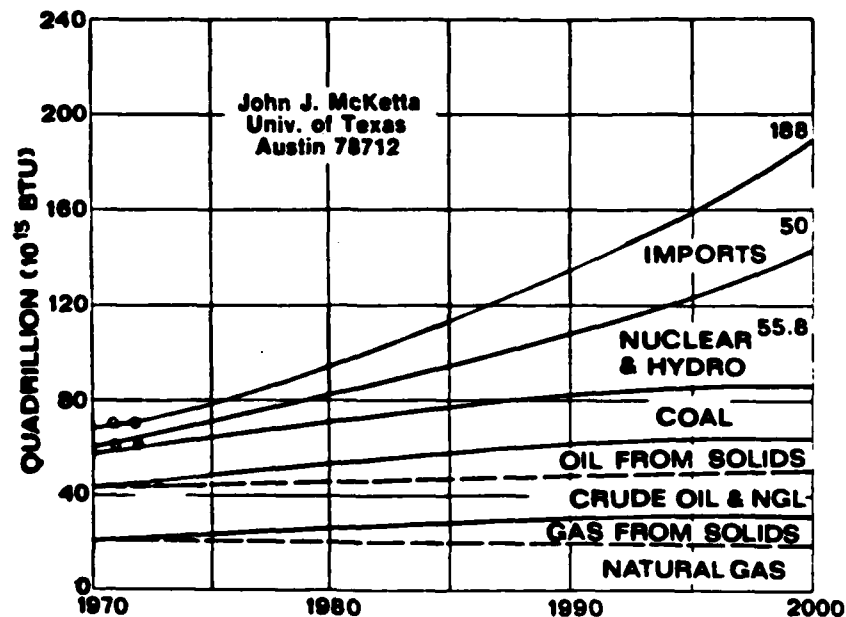


Figure 1: McKetta Report Prediction of U.S. Energy Use
(24)

What we as a society (including architects) fail, even refuse, to realize is fossil fuel resources are finite. Sooner or later (actually sooner) there will be no more oil anywhere at any price (12). That fact, in and of itself, is not a tragedy. Waiting to prepare for life with very little or no oil is.

Architects have a unique responsibility in considering conscious and prudent use of energy in their designs. 'Architectural' energy use, or energy use in heating and cooling the residential and commercial sectors accounts for 33 percent of all U.S. energy consumption (2). Yet, again, architects shy away from effective energy design. Perhaps part of the reason is currently available energy analysis techniques, whether manual or computerized, are cumbersome and/or complicated to use. Many are based on extensive and slow 'number crunching'. Results are often in a numerical form not easily digested by architects. But perhaps of greatest distaste to Architects is the lack of connection between what they perceive as design and their creations' energy performance (many analyses can only take place after a project is completely designed).

The remainder of this chapter will review some representative building energy analysis programs and point out some of their shortcomings which EDECT has attempted to address. EDECT'S main features are summarized in the final section of this chapter.

1.1 Architectural Energy Analysis Techniques Sampler

In his book Computer-Aided Architectural Design, Mitchell gives an extensive list of discrete computer application programs for potential use in an architectural office (26). He suggests energy analysis should take place in the Sketch Design Phase:

BRIEFING PHASE

SKETCH DESIGN PHASE

Site Planning

Schematic Design Synthesis

Performance and Cost Analysis of Proposals

**Checking for Compliance with the Brief
Circulation Analysis
Preliminary Structural Analysis**

- * Heat Gain Computations
- * Heat Loss Computations
- Natural Lighting Computations
- Artificial Lighting Computations
- Sound Transmission Computations
- Preliminary Cost Estimation

Presentation

PRODUCTION DOCUMENTS PHASE

CONSTRUCTION SUPERVISION PHASE

MANAGEMENT FUNCTIONS

Although Mitchell presents his list as areas for computer applications, each phase and sub-phase could just as well apply to manual operations. Of important note is where he lists energy determinations - in the early stages of a project. There they can potentially do some good if the architect can and wants to use the results to modify the design in an attempt to improve energy performance. This process can be termed energy design (10). Few energy analysis techniques today encourage energy design. Most discourage it.

1.1.1 Commercial/Governmental Energy Analysis

Due to the complexity of detailed and precise building load analyses extensive research to develop load analysis systems has been sponsored by various private and federal agencies; most notably the Department of Energy (DOE). Though their methods vary, their usefulness as energy design tools share a commonality.

In addition to the involved load analysis systems, the government has developed the other end of the analysis spectrum - simplified, manual techniques;

The BLAST Approach

Complex computerized thermal load determination programs have been in use for several years (7,17). Representative of these is The Building Loads Analysis System (BLAST) (16). BLAST requires exhaustive input of all building characteristics in numerical form. Unless the designer is fortunate

enough to own an expensive copy of the BLAST program he must fill out several forms for shipment to the nearest BLAST analysis center - and wait. It may be days until the analysis is received, and often times instead of analysis the original forms are returned with requests for corrections. The results, like the input, are numerical. Communication is so hindered that one independent revision to ELAST attempted to improve the man - machine communication by providing overly simplistic graphics (Figure 2) to represent the input data.

Due to their complicated nature, BLAST type programs are strictly 'end line' systems; they are used as sparingly as possible and only after detailed knowledge of a design is known - after design is completed! Also, in most cases, special training is needed to operate these systems so one person becomes the specialist and the designers never come close to it (41).

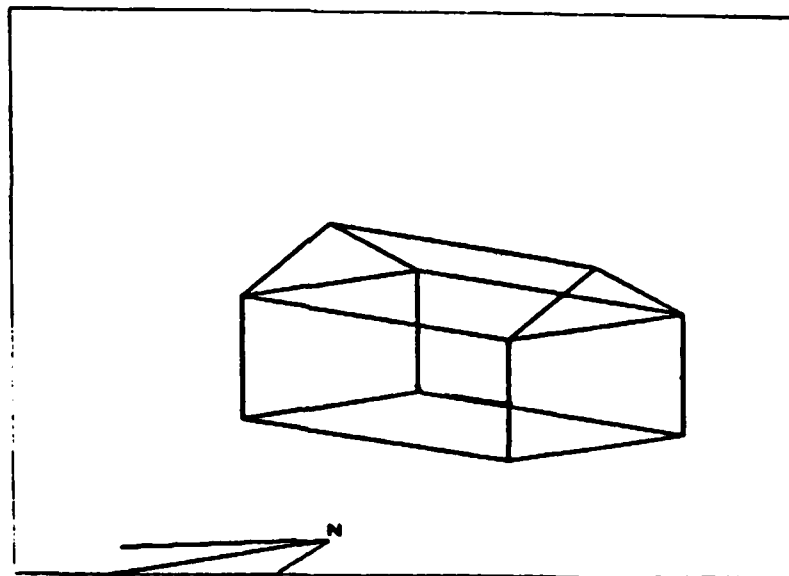


Figure 2: BLAST Graphical Input
(16)

Pocket Calculator Energy Analysis

Though much less complex and expensive than the systems described above, pocket calculator programs such as LEL, SCOTCH, and TENANT suffer from many the same hindrances (19); they are based on numerical input/output only, a detailed knowledge of the building is required before input, and only one building can be analyzed at a time. They are also 'one-pass' programs in that to do more than one analy-

sis of the same basic design the entire data representation must be input every time. Minor changes can not be input alone and the program rerun.

DOE's Predesign Energy Analysis

At the 'low-tech' end of the analysis spectrum are a few manual systems represented most notably by DOE's graphic approach to energy conscious design (36). This predesign energy analysis is a series of straight forward forms which are filled out / charted by the designer after project programming has been completed. After only a short initiation with the graphic results (Figure 3) good initial ideas on energy performance can be formulated. Calculations have been kept to the barest minimum for the sake of speed and user friendliness. However, despite all efforts to speed up the analysis it still requires a discouraging amount of time and although the results can be seen graphically (thus understood quicker) the starting information is still numeric and does not give the designer the visual 'feel' for his energy decisions.

Total Building Energy Performance

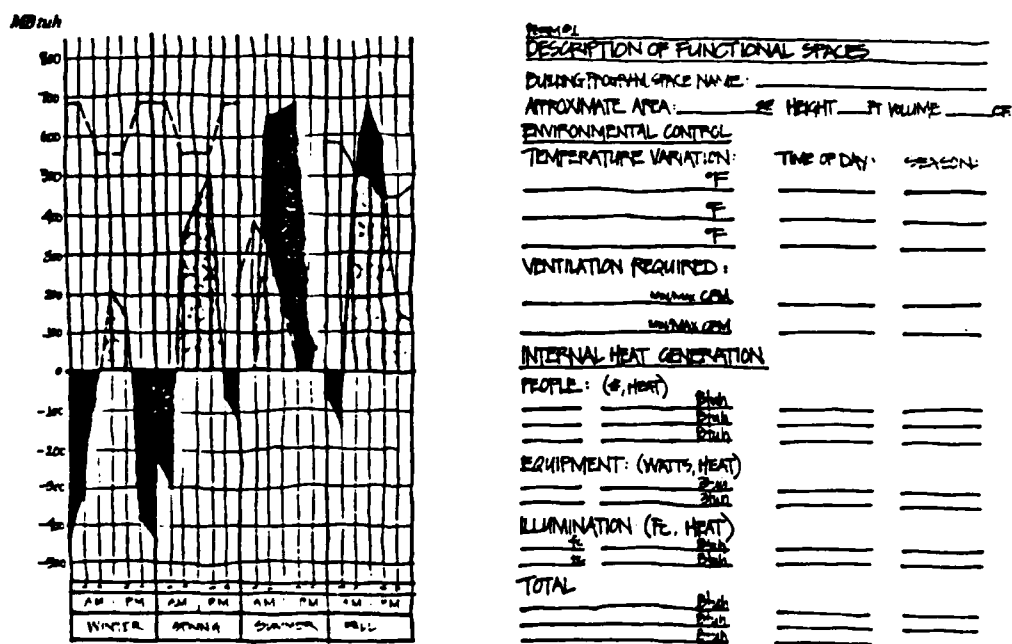


Figure 3: Sample Forms for DOE's Predesign Energy Analysis (36)

SOLAR5

In concept, DOE/UCLA's computer program SOLAR5 is similar to DOE's Predesign Energy Analysis. Input of the design to be analyzed is strictly non-graphic and can be done at a early, programming design stage (25). SOLAR5's analysis and graphic results (Figure 4) are more sophisticated than the DOE approach and its analysis naturally much quicker. Of important note, SOLAR5 does not require the user to re-enter all design parameters before subsequent analyses, only the parameters being changed.

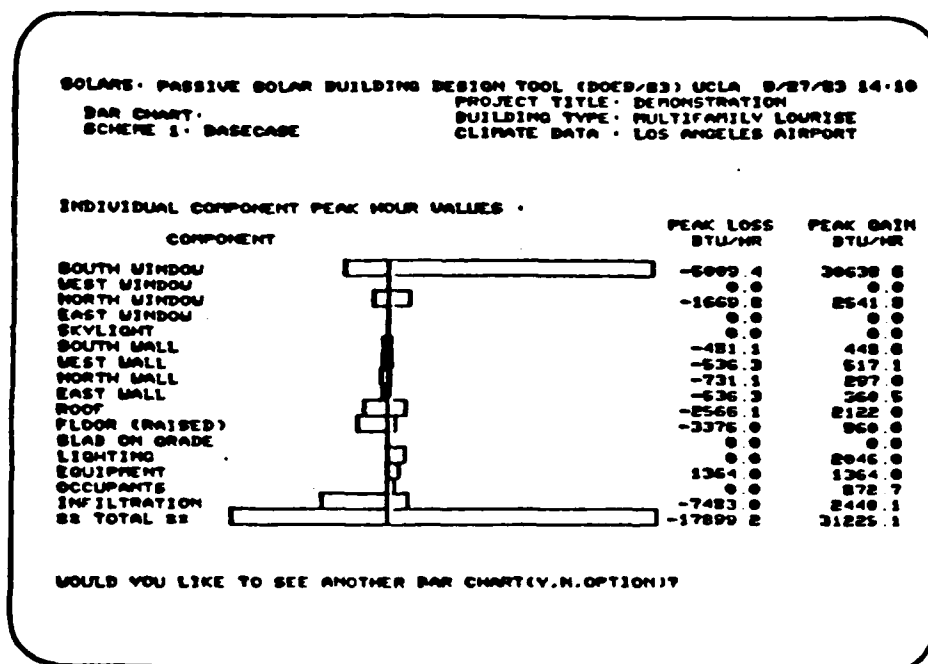


Figure 4: A SOLAR5 Graphic Analysis Chart (25)

1.1.2 Academic Energy Analysis/Design Systems

Where SOLAR5 was a joint DOE - UCLA research venture, a few energy related systems have emerged solely from the educational arena;

Two Systems from Academia

Two of the most recent exhibit some of the shortcomings described already. The University of Arkansas reports a system under development which extracts areas and R-values

from "special" AutoCAD drawings and produces analyses in a tabular alphanumeric form using Lotus 1-2-3 micro computer software (20). No mention is made of the ease with which changes are made but the output is strictly numeric and not instantaneously interpreted. Apparently too, the program is limited to heat loss analysis. (Figure 5)

			: EXPORTED FILE									
			NAME	TA	YA	BT	BY	R	HT	U	H	
TEMP DIFF (deg F)	75		WALL10	113	132	0	288	10.0	8.0	0.0	0.0	
			WALL19	113	420	480	0	19.0	8.0	0.0	0.0	
TOTALS	AREAS	HEAT LOSS	WALL19	393	420	0	-192	19.0	8.0	0.0	0.0	
	sqft	Btus/hr	WALL26	393	228	-288	0	26.0	8.0	0.0	0.0	
WALLS (net)	837	4,034	WALL26	305	228	0	-96	26.0	8.0	0.0	0.0	
WDS & DOORS	187	8,254	WALL10	305	132	-192	0	10.0	8.0	0.0	0.0	
SLABS/ROOFS	1,613	3,687	SLAB	119	139	183	273	50.0	0.0	0.0	0.0	
			SLAB	308	231	279	181	50.0	0.0	0.0	0.0	
TOTALS	2,637	15,995	ROOF26	98	121	216	316	26.0	0.0	0.0	0.0	
			ROOF26	317	217	287	220	26.0	0.0	0.0	0.0	
			WDM1	204	132	1	1	0.9	6.0	6.5	1	
			WDM2	393	334	1	1	1.7	8.0	4.3	1	
			WDM3	439	228	1	1	2.8	16.0	4.5	1	
			DOOR	113	391	1	1	2.0	3.0	7.0	1	
			DOOR	305	156	1	1	2.0	3.0	7.0	1	

Figure 5: Heat Loss Analysis Output - U. of Arkansas (20)

Rensselaer Polytechnic Institute (RPI) is attempting to computerize DOE's Graphic Analysis system to eliminate the manual system's slowness (31). Output from RPI's system is similar to the manual graphs (Figure 6) except they're done on a dot matrix type printer. The other manual Graphic Analysis shortcomings (non-graphic input, etc.) still remain.

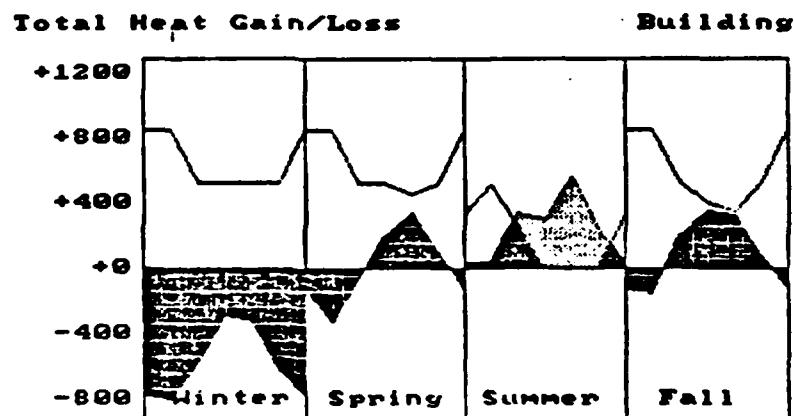


Figure 6: Energy Graphics Output - RPI (31)

Highlander's CEED

The problem of non-graphic input for energy design was tackled in the Ohio State University's Master of Architecture thesis by D. Highlander (15). CEED (A Computer-Aided Energy Efficient Design Program) made extensive use of interactive graphic techniques (menus, icons, cursor input, etc.) to allow the user to visually define/redefine the energy aspects of a building prior to analysis (Figure 7). The actual analysis was carried out by the NBSLD (National Bureau of Standards Load Determination) program running on the campus mainframe computer. Once again, though the input was more architecturally oriented, the output was numeric only. Also only one design could be analyzed and evaluated at a time.

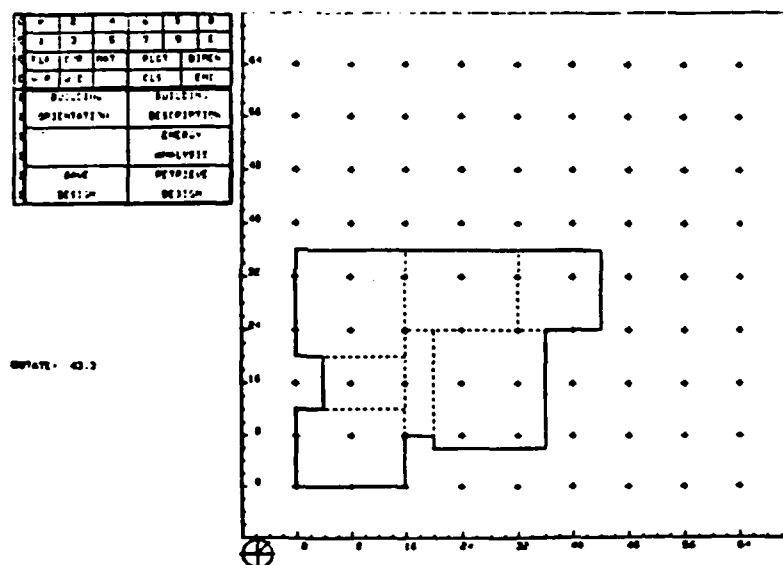


Figure 7: CEED Sample Input
(15)

Pittman's Energy Design Environment

The most notable attempt at a true energy design system (in or out of the academic arena) was J. Pittman's Master of Science thesis at Cornell (30). Pittman understood the barriers to true energy design and compiled a powerful combination of existing and new programs to overcome them. His interactive graphics environment uses a variety of input/output devices/methods (including raster and vector screens) (Figure 8) to simplify and 'architecturalize' energy design and analysis.

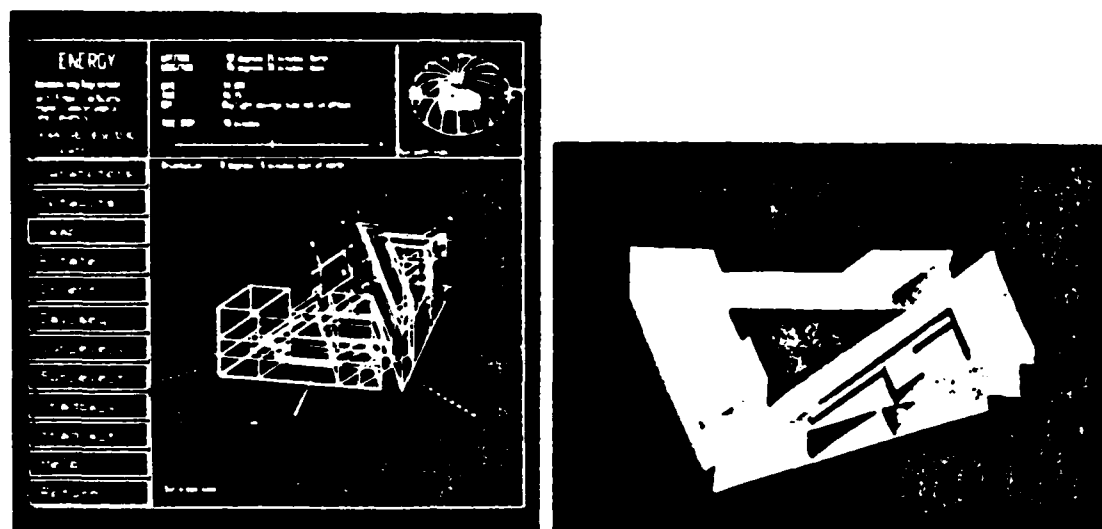


Figure 8: Sample Screens from Pittman's Energy Design (30)

Yet the Energy Design Environment apparently falls short in two key areas. First it does not allow complete building definition, specifically openings (a most important architectural and energy feature) can not be added, deleted or manipulated. And secondly it does not allow simultaneous comparison of alternative designs. The user must somehow remember results from one comparison to another.

1.2 The Energy Design Potential

This sampling is small, yet indicative of the numerous energy analysis programs for architecture. Many attempts have been made but most, if not all, fall short of being a powerful energy design tool. The computer does away with time consuming calculations yet many commercial systems do nothing more than 'number crunch', and computerizing energy design is potentially much more. A bare minimum list of energy design qualities should be as outlines below (1):

1. Perform rapid energy calculations of schematic design.
2. Produce legible and attractive output
3. Perform simulations of alternatives (in less than an hour !)

4. Accelerate a designers experience.

The goals set for the creation of EDECT were to implement a computer aided design system which allows the user to interactively and graphically design/redesign the aspects of a building model which most affect energy consumption. Those aspects include fenestration, shading devices, material selections, and orientation. At any time during an EDECT design session rapid graphical and/or numerical analyses can be done on any model in EDECT memory. The graphical analysis is an easily interpreted, three dimensional graph and the numerical analysis has an abbreviated summary as well as a detailed breakdown of heat gain and heat loss. Up to four different designs and their graphical analyses can be compared side by side. EDECT also makes key analyses of a design's perimeter vs. area and fenestration and explains the meaning of the analysis.

Thus EDECT endeavors to meet or exceed the four qualities listed above. The designs EDECT uses are schematic and the EDECT user can make changes to them. EDECT's output not only is attractive and legible but the graphic analysis is in a form easily understood and digested. The simulations performed by EDECT are done in seconds, not hours. And hopefully through EDECT analyses and explanations the user/designer will soon gain an intuitive feel for good energy design decisions.

This thesis consists of six chapters, including this introduction. The next chapter, Chapter 2, overviews the concepts, terms and user interactions of EDECT. Chapter 3 is a user's manual. Chapter 4 gives an example EDECT design session. Chapter 5 deals with EDECT's internal operations by covering data structures, calculations, and algorithms. The last chapter presents possible extensions to EDECT and a conclusion.

2. EDECT Overview

This chapter previews the Energy Design Evaluation and Comparison Tool (EDECT) by covering the concepts behind its creation, why it does what it does and why it does not do other things. Typical operations and terminologies are also presented as a basis for the User's Manual presented in Chapter 3.

2.1 Architectural Energy Elements

In terms of the causes of heating and cooling loads, buildings can be divided into two basic categories; envelope dominant and load/system dominant (4). Envelope dominant buildings are buildings whose major impacts on energy use are climatological (high and low temperatures, wind, rain, snow, etc.) and thus the outside skin or envelope is the main determinant. Residences, small to medium offices and retail stores, and private clinics are envelope dominant examples. Conversely, system dominant buildings' major energy loads come from within. Large number of occupants, special manufacturing/processing operations, and unique man-made environments are examples where the interior functions cause more heat gain/loss than the weather. Compensating for system dominant loads becomes a mechanical rather than architectural design problem. EDECT deals effectively with envelope dominant design types.

Envelope dominant energy design is made up of building elements which significantly affect both energy performance and building design (10). While nearly every aspect of architectural design can have some impact on energy consumption, the following lists the major components:

Roofs

The roof of any building is in more direct exposure to incoming solar radiation (insolation) than any other surface of the envelope. It is also where snow collects and rain falls. The materials a roof is made up of determine how effectively it resists the flow of heat, either in or out.

The most effective of those materials is insulation, however many designers have the misconception that more insulation is better. Insulation's resistance to heat flow does not increase linearly with thickness, in fact the economic payback of most types of added insulation after a few inches drops off dramatically (38).

Walls

Though not as impacted by the natural climate as roofs, the exterior building wall in many cases has more exposed square footage and has a thickness determined by esthetic considerations rather than energy (38). Since most walls do have at least some cavity space, prudent use of insulation in those cavities is necessary, in fact demanded by code in some states.

Openings

Where roofs and walls provide an insulated barrier to the elements openings in that barrier, specifically doors and windows, are like holes in a bucket of water. And like water, heat flow will take the path of least resistance - through an opening (32).

Doors are normally more resistant to heat flow than windows, but both cause infiltration gains/losses; e.g. the perimeter around the opening is a crack through which air passes. There is no perfectly airtight opening, nor for health reasons should there be. Extra panes of window glazing improve the insulation qualities but like roof and wall insulation too much is not economical. Windows or glass doors exposed to direct insolation also contribute greatly to interior heat gain (33).

From an energy performance standpoint it may seem logical to do away with openings since they are by far the single most detrimental building factor. But of course from a design standpoint that would be ridiculous. Good energy design dictates a compromise.

Overhangs

Related to the glazing insolation problem and the shading of direct sunlight in general are overhangs/projections. Proper placement and size of overhangs can cut out damaging (during a cooling season) insolation and let in beneficial (during a heating season) insolation. And of course projections can provide aesthetic relief to a wall surface.

Orientation

A building's orientation is not an architectural element in and of itself but directly influences all the above mentioned elements. A change in orientation by only a few degrees can expose some surfaces/openings to insolation and turn away others thus changing energy performance dramatically (27).

Perimeter vs. Area

Like orientation, perimeter vs. area (P vs. A) is not by definition a single architectural component, but rather a combination of components. Two buildings can have the same square footage of floor space but have very different linear feet of perimeter (Figure 9). More perimeter means more exposed exterior building envelope and subsequently more heat transfer.

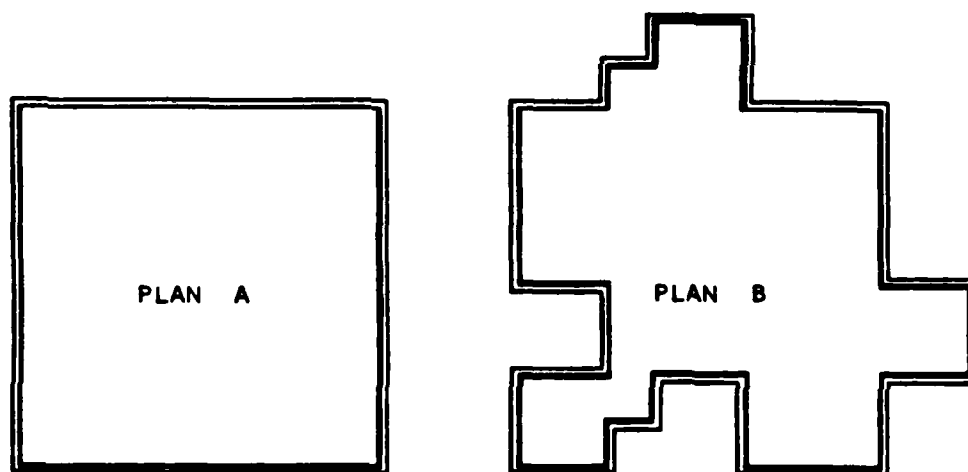


Figure 9: P vs. A Illustration

2.2 What EDECT Does

EDECT enables the user to manipulate the critical energy elements of an envelope dominant design type - roof/wall construction types, openings, and overhangs - then instantly view the resulting energy performance graphically or numerically. The graphical analysis is in an easily interpreted 3D form. Orientation, though not a building element per se, can likewise be changed by the user. To do an annual energy analysis EDECT allows user definition of macroclimate, building type, mechanical system, lighting system, and number of occupants. For the sake of rapid comparison analysis, default values exist for element and building system definitions. Up to four graphical analyses can be compared side by side. And finally, upon user request, EDECT will analyze and explain the performance of the most critical elements: north fenestration, south fenestration with overhangs, and a design's P vs. A.

2.3 What EDECT Does Not Do (and Why)

EDECT is not a complete modeling tool and relies on ARCHIMODOS (The Architectural Modeling, Design, and Drafting System of The Ohio State University) for initial object definition. P vs. A is influenced by the exterior wall configuration as designed on ARCHIMODOS and therefore can not be reworked by EDECT. Lessons learned from EDECT on improving P vs. A ratios must be applied in future ARCHIMODOS modeling sessions.

EDECT is not a mechanical design tool and does not do detailed mechanical system sizing, duct sizing and layout, etc. That type of design is more critical to load dominant building design and EDECT only deals with envelope dominant design accurately. Likewise EDECT's analysis technique is accurate yet simplified to speed comparison and analysis. EDECT is intended for use in early design where pinpoint performance accuracy is not necessary. In fact it has been shown the long, intricate analysis techniques do not produce exact results because they can not simulate all fluctuating field conditions (4). Simplified techniques have proven nearly as accurate at predicting energy performance as complex ones (11).

2.4 EDECT's Analysis Technique

EDECT's method of energy use evaluation is patterned after the American Institute of Architects' (AIA) Simplified Energy Evaluation (SEE) technique. SEE is a straight forward analysis which yields accurate results and is very adaptable

to the architectural modeling or schematic design phase but can also be a valid energy design tool in later design phases (2). SEE is also useful as its results can be presented graphically.

2.5 The ARCHIMODOS Interface

EDECT acts as a 'boot' program to ARCHIMODOS in that ARCHIMODOS must be run first and a model(s) generated on it before EDECT can be run. The models created by ARCHIMODOS are saved in a common disk storage area and picked up by EDECT from that same disk storage (see Appendix C for detailed disk storage information). Once residing in EDECT the model data can be manipulated and analyzed for energy performance as often as the user desires (Figure 10). EDECT can also save to disk model and alphanumeric data peculiar to its operations, however this data is not compatible with ARCHIMODOS operations and can not be used by the modeler.

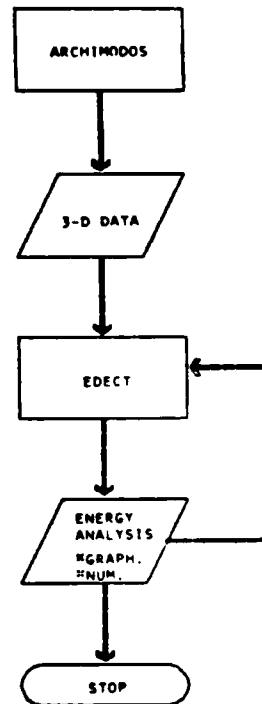


Figure 10: ARCHIMODOS - EDECT Flow Chart

Although ARCHIMODOS model data containing doors, windows and interior walls is read by EDECT, immediately after reading interior walls/wall surfaces, interior roof/floor surfaces and exterior door and window side faces are culled out of display data so the resulting image is the envelope shell with outlined openings. (Figure 11) This culling simplifies

the viewing image giving the user only the visual information needed for envelope dominant energy design. In addition to the display culling, all exterior opening data is placed in its own data structure for later EDECT operations (see Chapter 5).

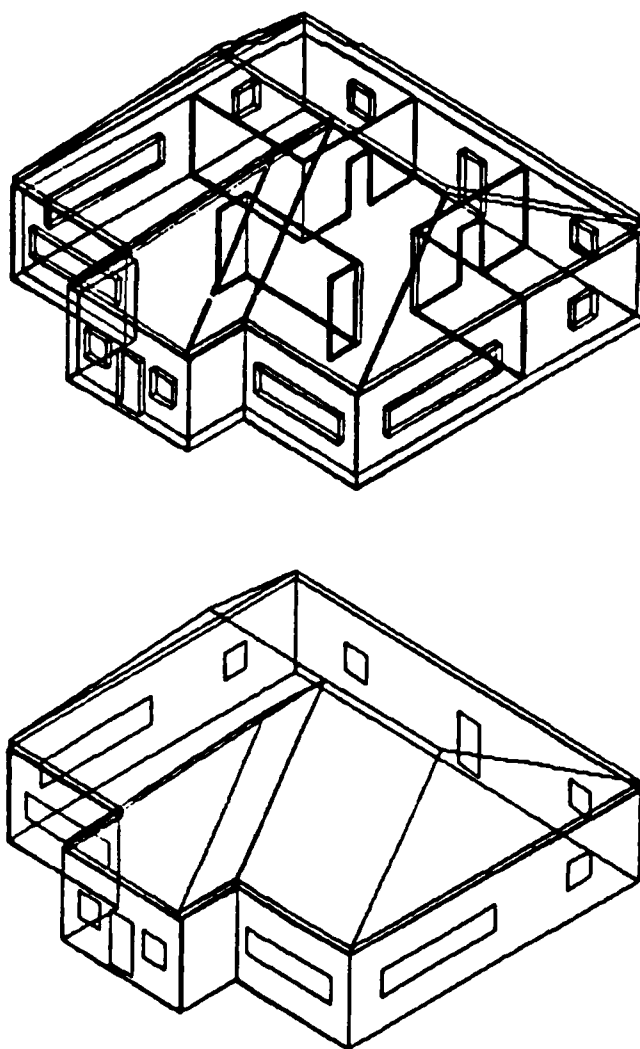


Figure 11: Model Before and After Culling

2.6 Hardware and Software

The devices and drivers at the OSU CAAED Lab used by the EDECT system include an IBM 4341 computer running VM/CMS. The program consists of approximately 10,000 lines of Fortran IV code with graphic support from IBM's GSP (Graphic Subroutine Package).

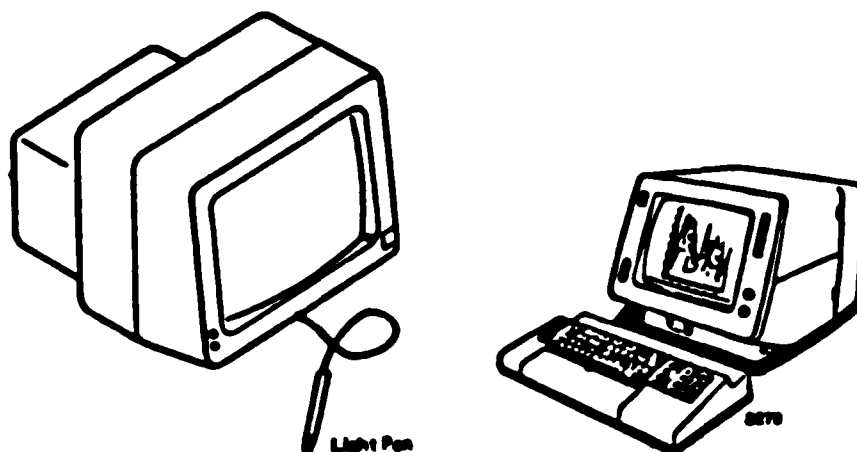


Figure 12: The EDECT Workstation
(40)

The actual EDECT workstation (Figure 12) is made up of an IBM 3251 vector refresh graphics terminal with light pen for user interaction, and an IBM 3279 color raster graphics terminal. The 3251 refresh terminal provides all the system's graphic display and interaction capabilities. The 3279 terminal displays error messages and other non-graphic user information such as an in depth energy analysis tabulation. The 3279 is also the communication device through which the user initiates program execution (see Appendix C).

2.7 EDECT Implementation

This section gives a graphic preview to the user - EDECT interface. Key figures and explanations give an overall idea how the user and EDECT manipulate the important envelope design elements and interpret the analysis results to improve energy design. A detailed user's manual is presented in Chapter 3.

2.7.1 The Basic Screen

Upon initializing EDECT and throughout an EDECT session the basic screen - on the 3251 - (Figure 13) is 'home base' for the user. The Object Data Box holds basic graphic and alphanumeric description of the model (object) currently under consideration; the Object List Area displays the names of all objects in session memory or all unused object names - depending on the command selected; the Commands Area lists primary and secondary system commands (Figure 13 shows the primary command menu); the Graphics Area displays a variety of graphic/alphanumeric information (see following figures); and the message box gives the user various error, prompt, and general information messages (see Appendix B).

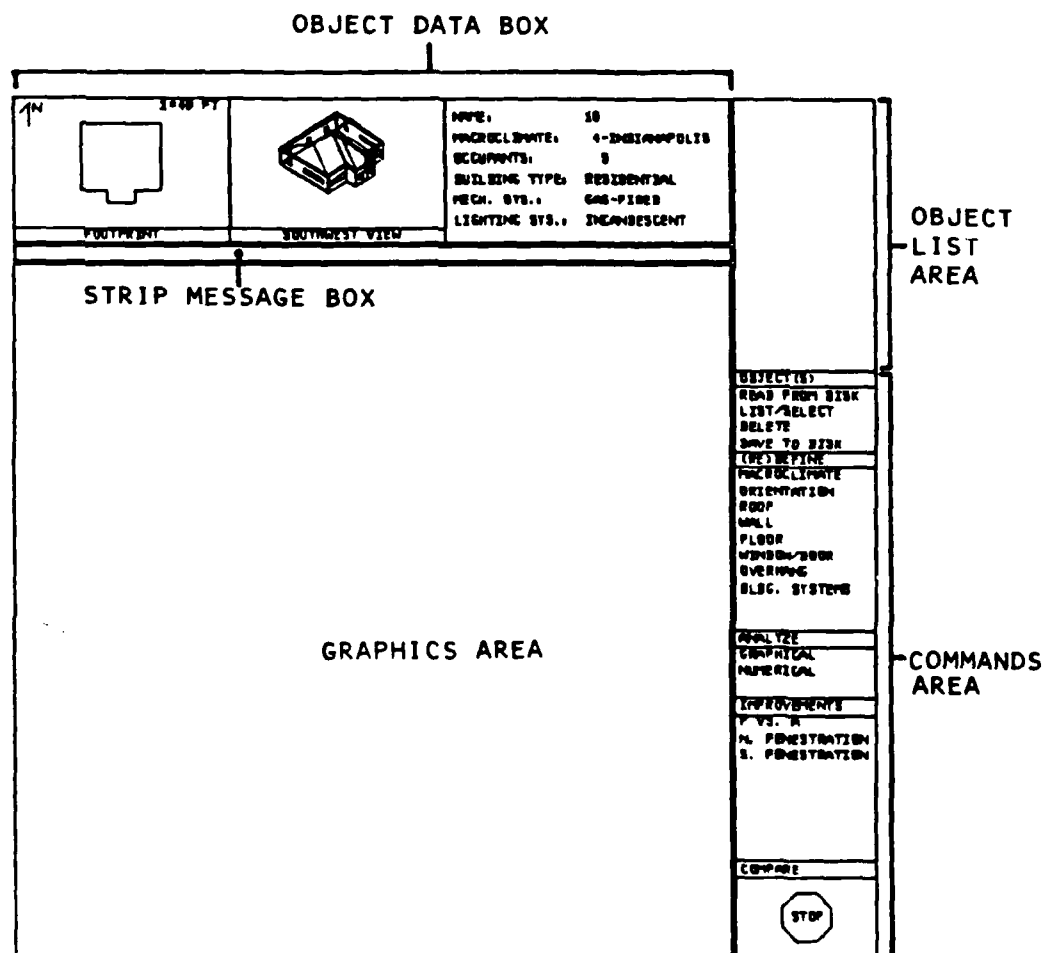


Figure 13: The Basic EDECT Screen

All user communication with the screen (picking commands etc.) is done with the light pen. The remaining sections on implementation deal with the Graphics Area.

2.7.2 The Macroclimate

Studies have shown that for the basis of design the United States can be divided into sixteen distinct macroclimates (2). Macroclimates are grouped into geographical regions based on similar weather data. EDECT's macroclimate selection screen (Figure 14) is provided mainly so EDECT can perform a yearly analysis if requested. Though a climate will dictate different energy design strategies seldom does the architect choose where a design is to be built. Therefore the macroclimate choice is not a designer manipulatable element.

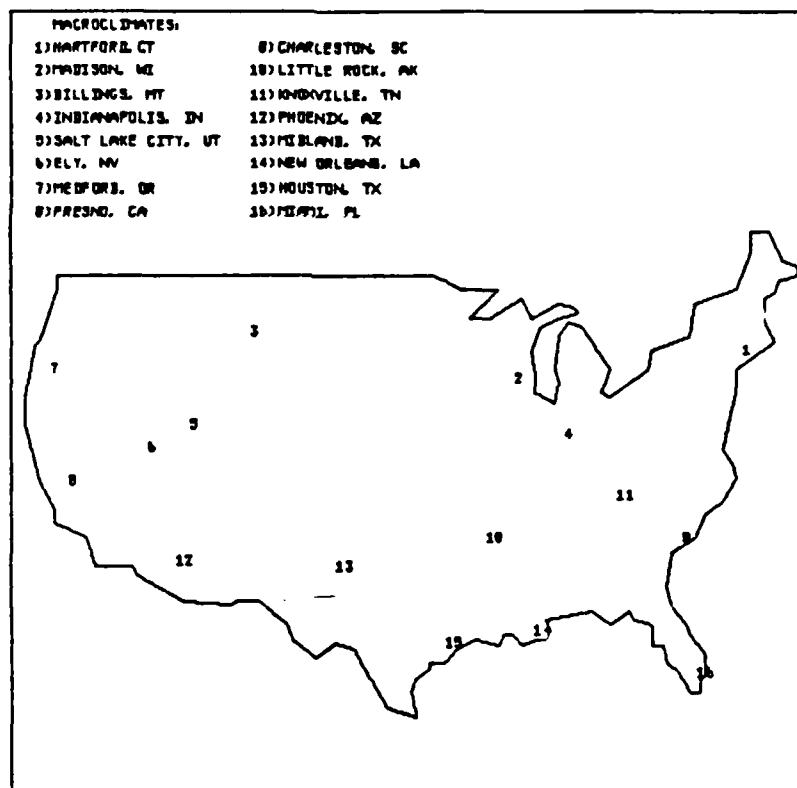


Figure 14: The Macroclimate Graphic

Obviously not all U.S. cities are shown on Figure 14. If the city a design is planned for is not one of the sixteen macroclimate cities the user must choose the macroclimate city closest to the actual city.

2.7.3 Orientation

EDECT's orientation routine is multi-purpose. Not only does it provide the user with four separate windows for up to four simultaneous orientation changes/comparisons of the same object (Figure 15) but can also make copies of existing objects for comparison/alteration purposes.

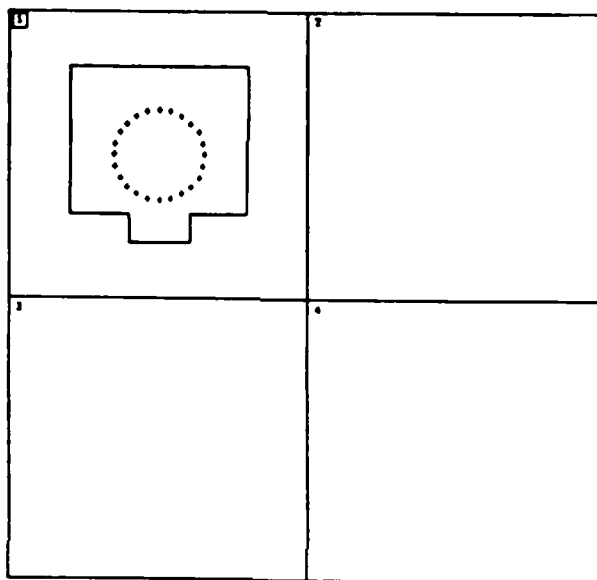


Figure 15: The Orientation Graphic with Object Footprint

2.7.4 Roof and Wall Construction Types

The selection of roof and wall construction types are done from similar screens (Figure 16) where the user can pick from a menu of available types. While a roof is considered to be of only one construction type an object's walls can be all one type or each individual wall can have a unique cross section.

A survey of different architectural energy analysis approaches points out the advantage of providing a menu of common construction types to pick from as opposed to allowing the user to 'build' cross-sections from a menu of individual materials. In the haste to improve performance designers tend to disregard practical structural and economic considerations and create impossible or unecorrcical cross-sections. By providing a variety of complete, practical and safe construction types a system ensures designs which can be built as well as analyzed (4).

**ROOF TYPE:
PITCHES W/ CATHEDRAL CEILING**

CURRENT CONSTRUCTION

AVAILABLE ROOF CONSTRUCTION TYPES:

- | | |
|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 1. 1 RIGID INSULATION 1 WOOD. | 8. BUILT-UP ROOF. 2 CELLULAR GLASS INSULATION 2 CONCRETE. |
| 2. 2 RIGID INSULATION 2 WOOD. | 9. BUILT-UP ROOF. 2 CELLULAR GLASS INSULATION 4 CONCRETE. |
| 3. 1 RIGID INSULATION 1 CONCRETE. | 10. BUILT-UP ROOF. 4 RIGID INSULATION 4 CONCRETE. 1/2 GYP BOARD. |
| 4. 2 RIGID INSULATION 2 CONCRETE. | 11. BUILT-UP ROOF. 4 CELLULAR GLASS INSULATION 4 CONCRETE. 1/2 GYP BOARD. |
| 5. BUILT-UP ROOF. 2 CELLULAR GLASS INSULATION 2 CONCRETE. AIR SPACE. 1/2 GYP BOARD. | 12. BUILT-UP ROOF. 8 CORK BOARD. 4 CONCRETE. 1/2 GYP BOARD. |
| 6. BUILT-UP ROOF. 2 CELLULAR GLASS INSULATION 4 CONCRETE. AIR SPACE. 1/2 GYP BOARD. | |
| 7. BUILT-UP ROOF. 4 CONCRETE. 2 CELLULAR GLASS INSULATION 2 CONCRETE. | |

AVAILABLE WALL CONSTRUCTION TYPES:

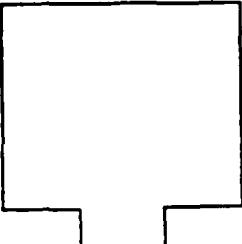
- | | |
|-----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| 1. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 AIR SPACE. 1/2 GYP BOARD. |  |
| 2. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 GYP BOARD. | |
| 3. 3/4 WOOD SIDING. 7/8 WOOD PURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 PANELING. | |
| 4. 3/4 WOOD SIDING. 7/8 WOOD PURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 7/8 WOOD PURRING. 1/2 PANELING. | |
| 5. 1 STUCCO. 6 CONCRETE. 1 GYP BOARD | 13. 8 BRICK/CONC. BLOCK. 2 RIGID INSULATION 1/2 GYP BOARD. |
| 6. 1/2 CEMENT PLASTER. 4 FILLED CONCRETE BLOCK. AIRSPACE. 4 FILLED CONCRETE BLOCK. 1/2 CEMENT PLASTER. | 14. 6 PRECAST CONCRETE SANDWICH PANEL. 2 POLYURETHANE CORE. |
| 7. 1/2 CEMENT PLASTER. 4 CONCRETE BLOCK. AIRSPACE. 4 CONCRETE BLOCK. 1/2 CEMENT PLASTER. | 15. 10 BRICK CAVITY WALL. 2 RIGID INSULATION IN CAVITY. |
| 8. 1/2 CEMENT PLASTER. 4 HOLLOW TERRA COTTA BLOCKS. AIRSPACE. 1/2 CEMENT PLASTER. | 16. 10 BRICK CAVITY WALL. |
| 9. 6 SOLID BRICK. 2 RIGID INSULATION 1/2 GYP BOARD. | 17. 10 BRICK/CONC. BLOCK CAVITY WALL. 2 RIGID INSULATION IN CAVITY. |
| 10. 6 HOLLOW BRICK. 1 X 2 PURRING. 1/2 GYP BOARD. | 18. 10 BRICK/CONC. BLOCK CAVITY WALL. |
| 11. 6 HOLLOW BRICK. 2 RIGID INSULATION 1/2 GYP BOARD. | 19. 4 BRICK VENEER. 1/2 INSULATION BOARD SHEATHING. 2 X 4 WOOD STUDS. BATT (R-11) INSULATION. 1/2 GYPSUM. |
| 12. 8 BRICK/CONC. BLOCK. 1 X 2 PURRING. 1/2 GYP BOARD. | |

Figure 16: Roof and Wall Menu Screens

2.7.5 Doors and Windows

EDECT's method of handling doors and windows treats both as openings in a wall. Depending on the type of door or window chosen the U-value will vary but the rest of the analysis for the opening - e.g. infiltration - is the same for both door and window. Because there is no major distinction between the two, only until (and if) the user selects door and window types does EDECT distinguish between the two.

The graphic interface for opening operations is done with two screens. One screen (Figure 17) is dedicated to changing opening size/position and adding/deleting openings.

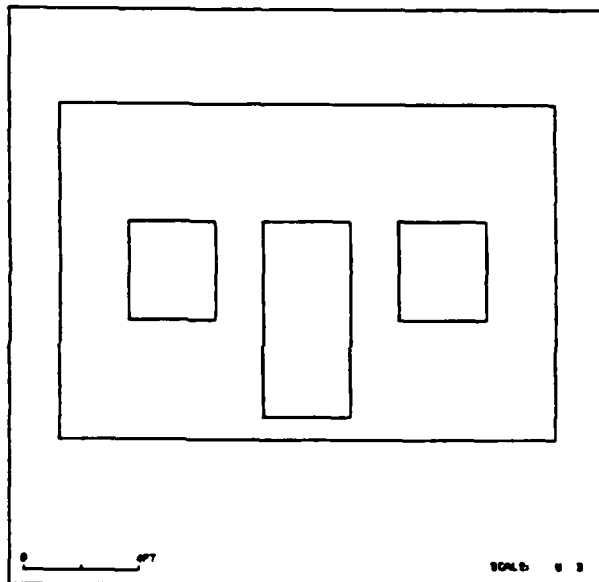


Figure 17: Opening Manipulation Screen

When the user has a tentative wall opening arrangement in the opening manipulation screen it can be transferred to one of two comparison windows in the opening definition screen (Figure 18). Besides giving the user a chance to visually compare and select from two different opening arrangement schemes, the definition screen is where the user can assign opening type and, if applicable, glazing. At any time during an EDECT session the user may return to this sequence and rework an object's openings.

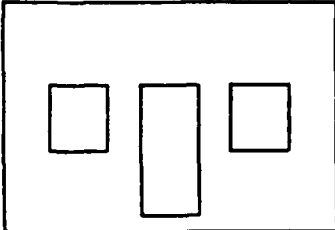
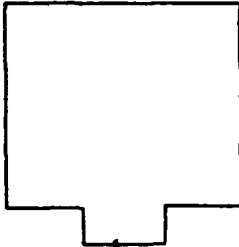
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Figure 18: Opening Definition Screen

2.7.6 Overhangs

Where openings are handled on the 2D surface of an elevation, overhangs are generated as projections to the walls of an isometric 3D object image (Figure 19). The isometric image with overhangs can be rotated in various clockwise and counter clockwise degree increments to give the user a sun like perspective of how much shading the overhang is doing. But because the sun's path varies from day to day and from season to season the isometric rotation, which is fixed, can not be taken as an accurate view from the sun.

Like opening manipulations, overhangs can be changed in size and wall position as well as be added and/or deleted. All EDECT's overhangs are rectilinear projections from the wall they are initially created on and any wall can have more than one overhang. Of course in the built environment overhangs and shading devices can take diverse forms and configurations. While EDECT can not model all possible overhang

types it can simulate the beneficial shading of most overhangs with reasonable accuracy.

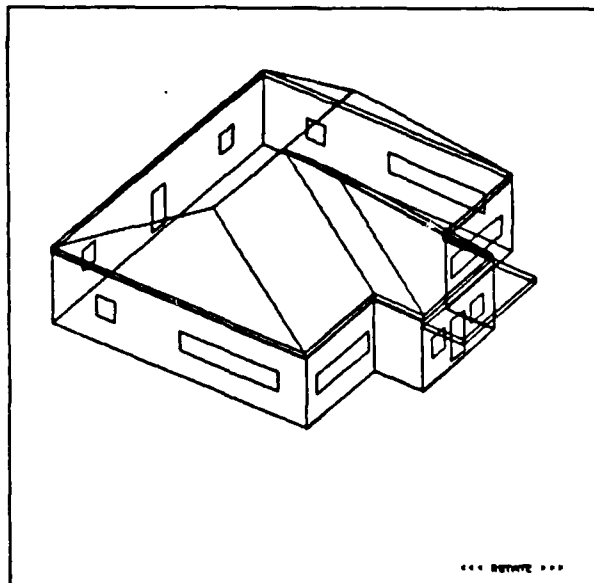


Figure 19: Overhang Manipulation Screen

2.7.7 Building System and Other Definitions

Like the macroclimate definition, other non-envelope aspects of the building must be defined (or defaulted) so EDICT can do an annual energy consumption analysis. These aspects are building type, occupants, mechanical system and lighting system. The selection menus for each are all part of one screen which is equally divided into four windows (Figure 20).

The building type choices are a representative but not all inclusive list of envelope dominant building classes. Different types represent different amounts of usage, e.g. a hotel/motel may be used around the clock where an office is normally used 8 - 10 hours in a 24 hour period and not at all on weekends and holidays. Building types with greater usage must use more energy to maintain comfort levels.

The number of occupants are picked in a cumulative manner in increments of up to 30 at a time. Thirty was chosen as the maximum increment because in many envelope dominant buildings there are 30 occupants or less (19). Of course the user may add up more than 30 occupants but then the design begins to become load dominant. Each occupant has a direct impact on energy used to condition and light the interior

environment as well as power possible production equipment/machinery.

The mechanical system menu lists the most common heating, ventilation, and air conditioning (HVAC) types. The various HVAC systems contribute to the cooling load by giving off varying measures of process heat. They also use energy sources (fuel, electricity, etc.) with varying efficiencies.

The lighting system options are likewise indicative of industry standard approaches to building illumination. EDECT is not an artificial lighting design tool so although a design may have more than one lighting system only one, preferably the most extensive, can be defined for SEE analysis and comparison purposes.

BUILDING TYPE: CLINIC COMMUNITY CENTER GYMNASIUM HOTEL/MOTEL APARTMENT RESIDENTIAL OFFICE RETAIL WAREHOUSE	OCCUPANTS: <table border="1"> <thead> <tr> <th colspan="6">(PICK)</th> </tr> </thead> <tbody> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> </tr> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td> </tr> <tr> <td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td> </tr> <tr> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> </tr> <tr> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> </tr> </tbody> </table> TOTAL: (RESET)	(PICK)						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
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Figure 20: Building Systems Screen

2.7.8 Graphical Analysis

One of EDECT's main features is the graphical form with which an object's envelope energy performance is presented. EDECT is intended as an architectural design system and

architects generally communicate graphically better than numerically. Certainly an architect would rather see a design than read its statistics or dimensions. For that reason the envelope energy results are presented in a three dimensional graph form, whose shape is indicative of good/poor performance.

The graphing method was set forth in the SOLAR5 analysis technique (25) and is two perpendicular (X and Y) axes corresponding to the 15th of every month and every hour in a 24 hour period. A 13 x 25 (the first month and hour are repeated) grid is created by the intersection of each axes' divisions and at each intersection point a Z value indicating the magnitude of heat loss or gain is calculated. By connecting all points of intersection with lines parallel to each major axis the image of free form surface or patch is created.

Two basic graph shapes show good and poor envelope energy design. A saddle shaped graph (Figure 21) signals good performance. When heat gain is most needed - during winter months - the building gets it, but proper shading of southern exposed openings prevent unwanted summer heat gain. Judicial use of north fenestration and envelope material selections prevent extremes in heat loss and gain. Poor performance, on the other hand, is symbolized by a 'heat mountain' (Figure 22) where undesirable heat is gained during summer months due to improper opening shading and desirable heat is lost during the winter due to combination of excessive north fenestration and inadequate envelope U-values.

After learning to judge performance graphs against these two extreme examples, and after a few experiments in trying to achieve a saddle shape graph a user rapidly learns how the envelope elements affect the graph, and can better make aesthetic and energy design decisions and trade-offs. It is important to note that EDICT suppresses and/or exaggerates graph Z values to achieve a relative uniformity between graphs of different objects. Thus a 'per capita' sort of visual comparison is attained. To determine actual heat loss and gain numerical analysis can be performed.

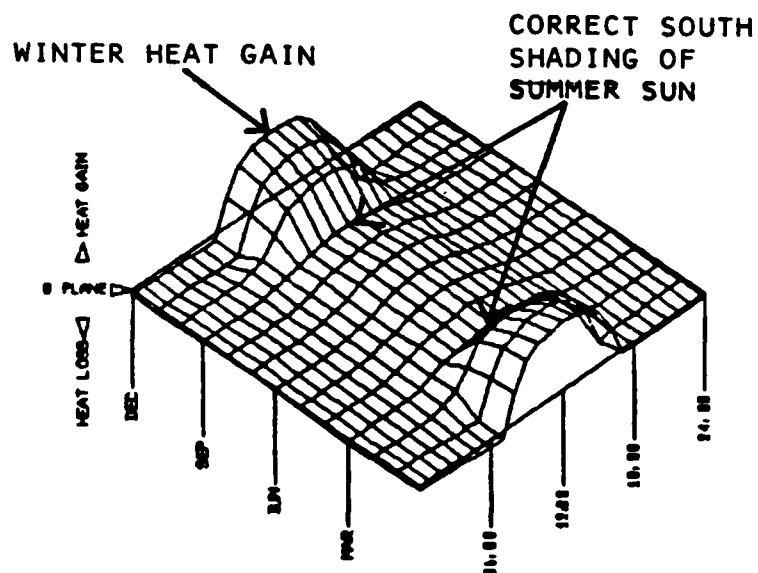


Figure 21: Good Performance Graph

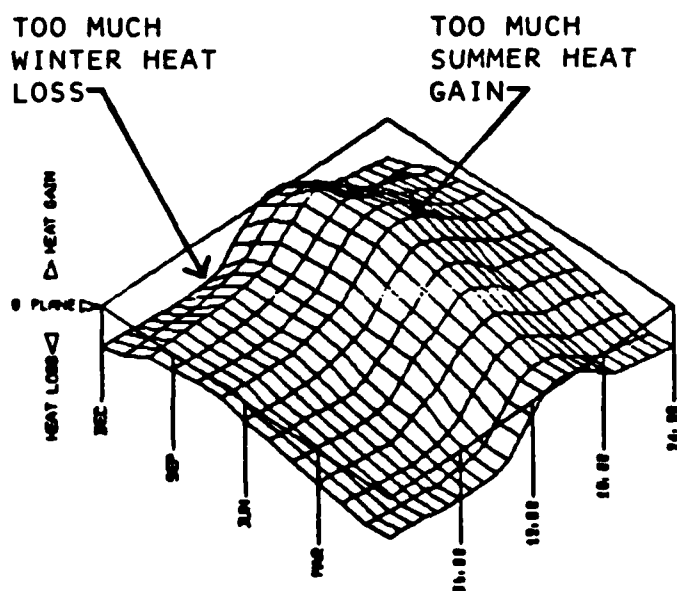


Figure 22: Poor Performance Graph

2.7.9 Numerical Analysis

EDECT does both an extended and abbreviated annual energy consumption analysis. The abbreviated analysis is actually a summary of key energy uses from the extended analysis. It appears as an alphanumeric screen on the 3251 display (Figure 23). EDECT's detailed analysis comes up on the 3279 color monitor and can also be saved on disk for hard copy retrieval after the end of a session (see Appendix A).

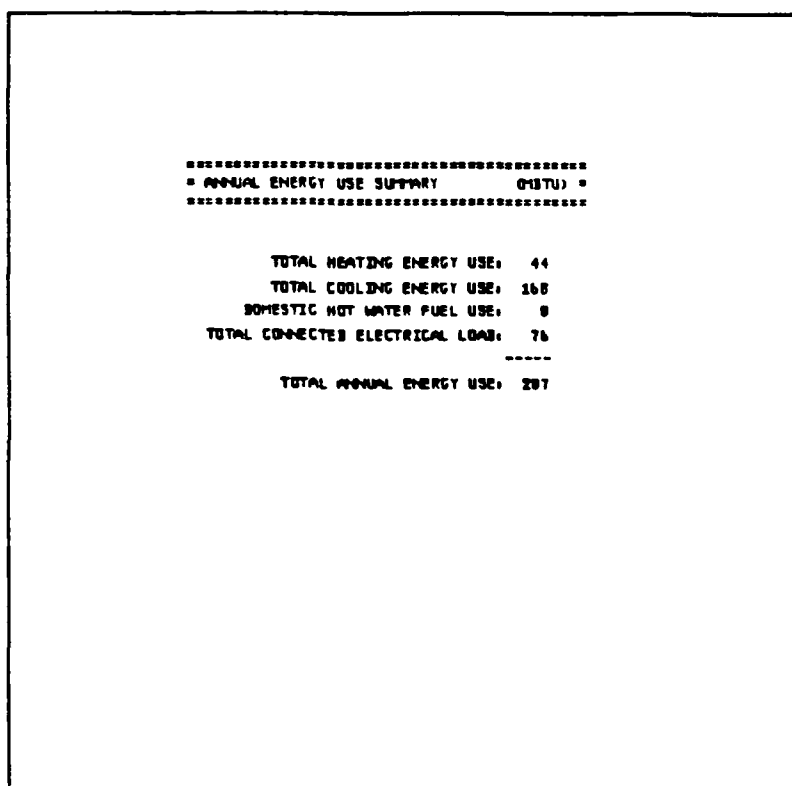


Figure 23: Annual Energy Use Summary Screen

2.7.10 The Comparison Capability

Another important EDECT feature is its faculty to display up to four graphical analyses of different energy designs simultaneously (Figure 24). This was considered almost essential since although a user could possibly remember or jot down a numerical result, graphical results are not as easily recalled and side by side comparison gives the designer flexibility and speed in arriving at better or optimum energy designs. Different 3D envelope energy

performance graphs may have only slight variations which can be best spotted in adjacent displays.

Each EDECT comparison display quadrant shows a labeled graph, object number, and isometric image of the object.

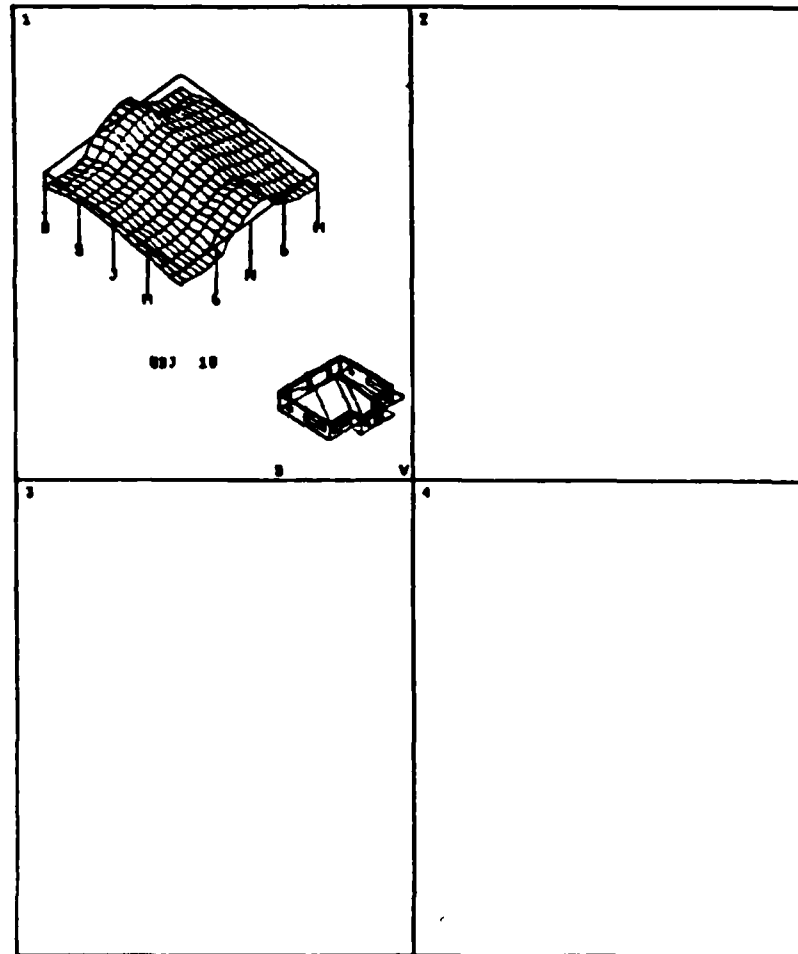


Figure 24: Graphic Comparison Screen

3. EDECT User's Manual

This chapter describes in detail the EDECT commands and interaction methods available to the user to design/redesign object models and evaluate their energy performance. The initial object creation is done with ARCHIMODOS and questions about its operations should be referred to the Archimodos User's Manual (40).

This chapter's first section explains the assumptions about an object EDECT operates on, and the second describes the primary and secondary menus. The remaining sections take the reader through EDECT explaining facets of the system along the way. The order in which this manual is presented basically corresponds to the order of commands in the commands area of the EDECT screen but should not be construed as the only sequence EDECT can run under. EDECT was designed to be flexible and allow the user to move throughout the system freely.

3.1 The Object

The variety of models that can be created using ARCHIMODOS is infinite. Some may even be massing studies with little or no structure imposed on them. For the sake of having an object model that can be evaluated even at a schematic design stage certain assumptions have been made:

- 1) The object has a continuous 'skin' or exterior envelope. This means that any holes in the walls must be made as a door or window. If an object were otherwise, i. e. with an uncovered opening, there would be little sense in doing an energy analysis on the design and attempt to reduce energy consumption.
- 2) The object must have a floor, (e. g. be generated on ARCHIMODOS as building model type 2, 4, 6 or 8).
- 3) The object must have a roof (for hopefully

obvious reasons). If the roof is to be flat, a type 4 building model can be selected or a flat roof may be simulated using ARCHIMODOS roof generation techniques. Both type 1 (solid) and 2 (shell) roofs can be used on objects sent to EDECT.

3.2 Primary and Secondary Menus

EDECT's key source of user input is through light pen activated command mnemonics. Each command represents a procedure or procedures carried out by the system. The user simply identifies the command desired and picks it with the light pen. With rare exception the user should never have to take his or her eyes off the 3251 screen to carry out an operation. Some procedures require more than one light pen pick and the Strip Message Box prompts the user for additional action. Use of EDECT will be eased considerably by reading and understanding the strip messages. Certain keywords in the strip messages are also light pen activated. Throughout this manual, strip messages (including error messages) will be referred to by number and sample strip messages are enclosed in parenthesis and in upper case letters. Appendix B lists all EDECT strip/error messages by number and briefly explains the cause of the error messages.

After successful system initiation, the first commands that come up in the Commands Area are the primary commands. Most primary commands are grouped into four categories: OBJECT(S), (RE)DEFINE, ANALYZE, and IMPROVEMENTS. COMPARE is a primary command rather than a category header. The four category headers are informational only and not light pen activated. When picked, certain primary commands cause the primary command menu to be temporarily erased from the command area and replaced with a secondary command menu. EDECT has five secondary command menus; Orientation, Wall, Window/Door, Overhang, and Compare (Figure 25). Each in turn holds more commands. Note that when picked, not every primary command causes a secondary menu to appear, but instead the primary command menu remains and light pen attention is called for elsewhere on the screen.

The following guide is grouped with the command category headers forming sections (e.g. 3.3) and primary commands forming subsections (e.g. 3.3.1). Further explanations are arranged as unnumbered listings under the corresponding subsection.



Figure 25: EDECT Primary and Secondary Command Merus

3.3 OBJECT(S) Commands Category

The first image the user sees on the 3251 is the basic screen shown in Figure 25. The Object Data Box, Strip Message Box, Object List Area and Graphics Area are blank. Before anything else can take place EDECT must have an object or objects to work with. Retrieving objects from disk, listing retrieved objects for selection, deleting objects from session memory and saving session data to disk are all accomplished by commands in the OBJECT(S) category.

3.3.1 READ FROM DISK

An EDECT session begins when this command is picked. All objects in disk storage are listed in the Object List Area and a strip message no. 1 (PICK OBJECT FROM OBJECT LIST OR (RETURN)) prompts the user to pick one of the listed objects (Figure 26). The 3279 display also gives the name of the 3D file if any. The object names are light pen activated and picking one makes it the current object. All subsequent EDECT operations will be performed on the current object until another object is picked.

AN	1000 FT	NAME:	1 2 3 4 5 6
		MACRODATE:	
		OCCUPANTS:	
		BUILDING TYPE:	
		MECH. SYS.:	
		LIGHTING SYS.:	
FOOTPRINT	SOUTH VIEW		
PICK OBJECT FROM OBJECT LIST OR			(RETURN)

Figure 26: Upper Screen After Picking READ FROM DISK

In the example session, there were 6 objects, named 1 through 6, saved on disk from ARCHIMODOS creation. When objects are read from disk storage into session memory, EDECT also checks disk files for object data from previous EDECT sessions. These EDECT files hold data on walls, windows/doors, overhangs, building systems. If the objects are being read by EDECT for the first time, 3279 messages will indicate these files are empty. If the user saves EDECT data before ending a session, later sessions with the same objects will read and use the saved data. Appendix C details disk storage operations.

If the user picks RETURN (in the strip message box) the screen returns to the state shown in Figure 25 and the

system waits for an object to be listed and picked. Picking an object (object 2 in the example) causes the object's footprint, isometric view, name, and any other data in memory to appear in the Object Data Box (Figure 27).



1N 100 FT  FOOTPRINT	 SOUTH VIEW	NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	

Figure 27: Upper Screen After Object is Picked

3.3.2 LIST/SELECT

In order to pick objects after the initial READ FROM DISK, this command must be selected. If the user picks READ FROM DISK more than once an error results and error message no. 1 is issued in the Strip Message Box. Picking LIST/SELECT yields the screen of Figure 26 but with the Object Data Box being filled with the current object's description. The user can then pick a new current object or keep the old one by picking RETURN.

3.3.3 DELETE

To erase an object from session memory, this command is chosen. The result is a list of all current objects and strip message no. 2 (DELETE OBJECT FROM OBJECT LIST OR (RETURN)) (Figure 28). If the user chooses not to delete an object RETURN brings back the basic EFFECT screen. Picking an object from the Object List Area erases all the object's data from session memory. This is not a permanent deletion unless SAVE TO DISK is picked before a session is terminated. One object can be deleted per DELETE pick. After object deletion, the basic screen returns and the deleted object's name becomes a possible selectee in the creation of new objects (see ORIENTATION subsection).



		NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	1 2 3 4 5 6
FOOTPRINT	SOUTH VIEW		
DELETE OBJECT FROM OBJECT LIST OR			(RETURN)

Figure 28: Upper Screen After Picking DELETE

3.3.4 SAVE TO DISK

This command saves all session object data to disk for use in future EDECT sessions. SAVE TO DISK can be picked as often as the user wants in a session but each save writes over the previously saved disk data. Before saving present data, EDECT verifies the user's intent with strip message no. 8 (ALL DISK NAMES WILL BE WRITTEN OVER. CONTINUE? (Y) (N)) (Figure 29). Picking N from the Strip Message Box will return the basic screen and Y will accomplish the save. The user may leave a message/label with the 3D data file via the 3279 monitor/keyboard. EDECT prompts for the message on the 3279 monitor and the user files the message with 2 'ENTERS' on the keyboard.



		NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT	SOUTH VIEW		
ALL DISK NAMES WILL BE WRITTEN OVER. CONTINUE? (Y) (N)			

Figure 29: Upper Screen After Picking SAVE TO DISK

3.3.5 Manipulating the Graphic Object Descriptors

The footprint and isometric view of an object can be altered

for easier viewing by picking the light pen activated scale and view selects (Figure 30). There are four scales which can be established in a cyclical manner;

1=90 FT -> 1=180 FT -> 1=20 FT -> 1=40 FT -> 1=90 FT

and three views which are also picked in cycle;

SOUTH -> SOUTHWEST -> SOUTHEAST -> SOUTH

It is recommended the scale that gives the largest image without clipping by the frame lines be arrived at as certain other EDECT operations fit graphic images to viewing windows at the object isometric view proportion.

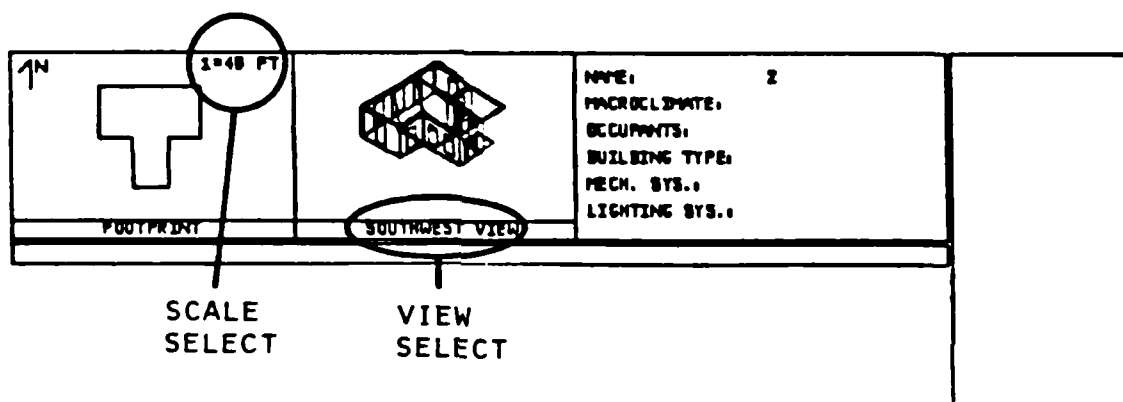


Figure 30: Graphic Manipulation in the Object Data Box

3.4 (RE)DEFINE Commands Category

EDECT's abilities to handle an object's energy elements and descriptions are controlled through the commands in this category. Some elements, like overhangs, may be defined for the first time. Others may be redefined from previous ARCHIMODCS or EDECT definitions.

3.4.1 MACROCLIMATE

To establish a weather zone where the design object would be built this command is picked. An icon of the United States with numbers at the macroclimate cities' location, a descriptive list of the cities and the number 16 strip message (SELECT MACROCLIMATE NUMBER FROM MAP. TO REGISTER SELECTION: (RETURN)) appear on the 3251 screen first (Figure 31).

While a macroclimate is being defined, the primary commands are inactive. The numbers on the states icon are light per activated and can be picked as an initial macroclimate definition. Whenever a macroclimate number is picked an indicator (>) is placed next to the number. Picking another number replaces the indicator next to the new selection. Picking RETURN finalizes the macroclimate choice by placing the macroclimate number and name in the object data box and returning the light pen active basic screen. The macroclimate can be redefined any number of times during a session. In the example session, macroclimate 8-Fresno, CA was picked. Macroclimate number 8 also happens to be the default macroclimate.

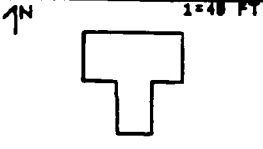

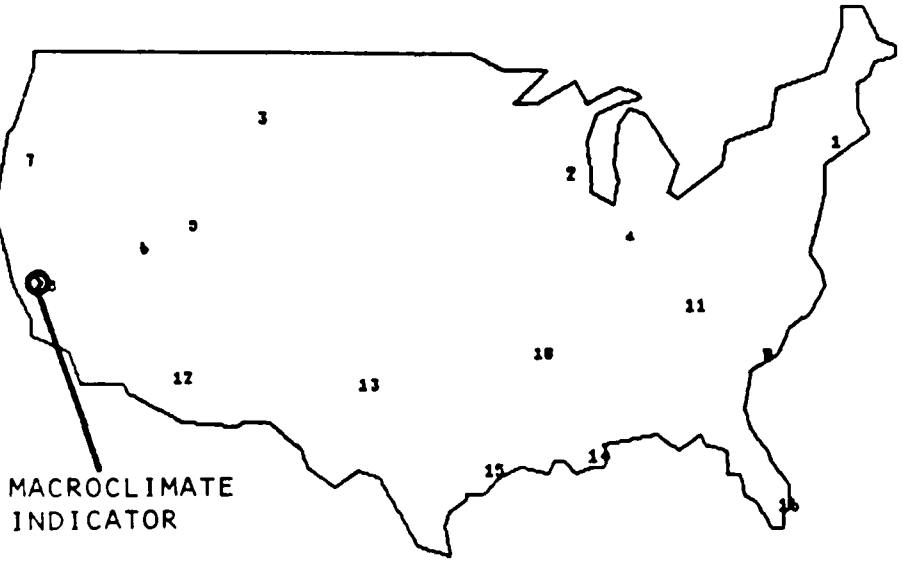

				NAME: MACROCLIMATE: 8-FRESNO OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT		SOUTHWEST VIEW			
SELECT MACROCLIMATE NUMBER FROM MAP. TO REGISTER SELECTIONS (RETURN)					
MACROCLIMATES: 1) HARTFORD, CT 8) CHARLESTON, SC 2) MADISON, WI 10) LITTLE ROCK, AK 3) BILLINGS, MT 11) KNOXVILLE, TN 4) INDIANAPOLIS, IN 12) PHOENIX, AZ 5) SALT LAKE CITY, UT 13) MIDLAND, TX 6) ELI, NV 14) NEW ORLEANS, LA 7) MEDFORD, OR 15) HOUSTON, TX 8) FRESNO, CA 16) MIAMI, FL					
					
MACROCLIMATE CHOSEN					
OBJECT(S) READ FROM DISK LIST/SELECT DELETE SAVE TO DISK (RET) DEFINE MACROCLIMATE ORIENTATION ROOF WALL FLOOR WINDOW/DOOR OVERHANG BLDG. SYSTEMS					
ANALYZE GRAPHICAL NUMERICAL					
IMPROVEMENTS F VS. A N. PENETRATION S. PENETRATION					
COMPARE					
					

Figure 31: Macroclimate Definition Screen

3.4.2 ORIENTATION

This command enables user defined (re)orientation of the current object or the reoriented object can be saved under a new object name. When a new object name is called for, all current object characteristics (openings, overhangs, building systems, etc.) are copied under that new name.



 <p>↑N 1=40 FT</p>		NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT SOUTHWEST VIEW			
SELECT QUADRANT TO DISPLAY IN OF MAIN MENU TO RETURN.			
1	2	MAIN MENU ACTIVE QUADRANT 1 2 3 4 (RE)ORIENT DEGREES -5 5 -15 15 -30 30 -45 45 -60 60 -100 100 CLEAR QUADRANT 1 2 3 4 SAME SAVE NEW SAVE	
3	4		

Figure 32: Initial Orientation Screen

The first 3251 display in the orientation procedure divides and numbers the graphics area into four equal quadrants, gives strip message no. 4 (SELECT QUADRANT TO DISPLAY IN OR "MAIN MENU" TO RETURN.) and replaces the primary command

menu with the orientation secondary menu (Figure 32). To bring the current object footprint into one of the quadrants for (re)orientation a two step command sequence must be followed. First make one of the quadrants active by picking its number under the ACTIVE QUADRANT command. The picked quadrant will be indicated with a box around the number in the quadrant. The active quadrant choice may be changed before the second step. The second step is to pick the command (RE)ORIENT which places a proportional footprint with rotation disk in the active quadrant (Figure 33). The rotation disk is for user reference with points placed in a circle at 15 degree increments.

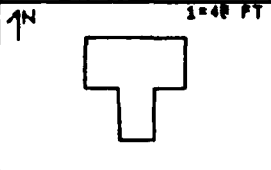

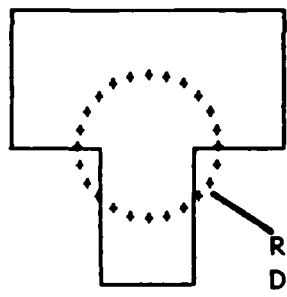
				NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT		SOUTHWEST VIEW			
PICK DEGREES OF (RETURN)					
<div style="border: 1px solid black; padding: 5px;">  </div>		<div style="border: 1px solid black; height: 150px; width: 100%;"></div>		<div style="border: 1px solid black; padding: 5px;"> MAIN MENU ACTIVE QUADRANT 1 2 3 4 (RE)ORIENT DEGREES -5 0 -15 15 -30 30 -45 45 -60 60 -75 75 -90 90 -105 105 -120 120 CLEAR QUADRANT 1 2 3 4 SAVE SAVE NEW SAVE </div>	
<div style="border: 1px solid black; height: 150px; width: 100%;"></div>		<div style="border: 1px solid black; height: 150px; width: 100%;"></div>			

Figure 33: Orientation Screen w/ Object Ready for Rotation

Once an object is in an active quadrant with the rotation disk the orientation can be changed by picking the degree of rotation number under the DEGREE command. Positive numbers indicate clockwise rotation in the degree indicated and negative numbers denote counter-clockwise rotation. Any combination of degree picks are allowed, and during rotation all commands but degrees of rotation are inactive.

When a tentative orientation has been arrived at, the user may reactivate the orientation secondary commands by picking RETURN in the strip message box. The (re)orientation process may be repeated for all remaining quadrants. To reuse a filled quadrant it must be first cleared by picking its number under the CLEAR QUADRANT command. Then the rotation process for that quadrant may continue.

The SAME SAVE and NEW SAVE commands allow the user to change the current object's orientation or create a new object. If SAME SAVE is picked EJECT will first prompt the user with strip message no. 6 (CURRENT OBJECT WILL BE WRITTEN OVER. CONTINUE? (Y) (N)). If the user picks N the strip message box is cleared and nothing happens. If Y is picked strip message no. 7 (SELECT QUADRANT NUMBER ORIENTATION TO BE SAVED) prompts the user to pick one of the quadrants as the current object's orientation. If a quadrant number is picked that quadrant's orientation becomes the current object's orientation. Only filled quadrants will have their numbers light pen activated.

Picking NEW SAVE first prompts the user with strip message no. 3 (PICK NAME FROM AVAILABLE NAMES LIST OR (RETURN)) to pick a new name from a list of unused names in the Object List Area or RETURN to the active orientation menu (Figure 34). If a new name is selected the system then prompts for the quadrant containing the desired orientation with strip message no. 7 (SELECT QUADRANT NUMBER ORIENTATION TO BE SAVED). As with SAME SAVE only a filled quadrant's number can be picked. Upon picking the quadrant a complete copy is made. If more copies are made the new name just selected does not appear as a possible new object name. Also in any later listings of objects in session memory the newly created object will appear.

For comparison or other purposes exact copies of an object can be made by rotating the current object a positive degree increment then an equal negative degree increment and finally saving the orientation as a new object. The entire (re)orientation process can continue until all 99 available object names are used or until memory is expended. Warning messages concerning memory size, if any, appear on the 3279 display.

The final command of the (re)orientation process is MAIN MENU which, when active and picked, returns the basic screen and primary menu.



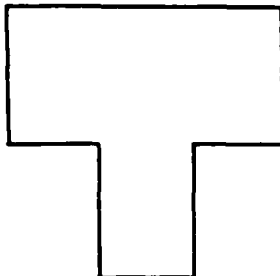
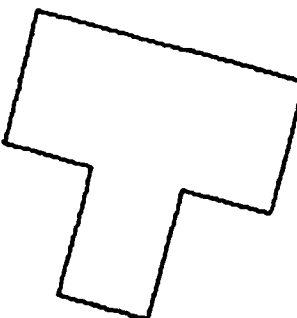
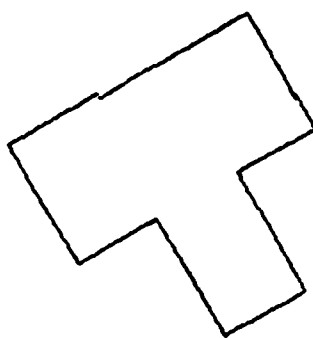
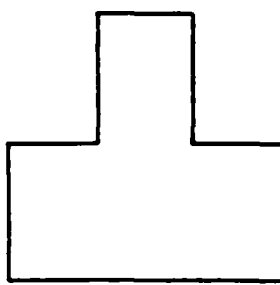
				NAME: 2 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99
FOOTPRINT		SOUTHWEST VIEW			
PICK NAME FROM AVAILABLE NAMES LIST OR (RETURN)					
1			2		
3			4		
					MAIN MENU ACTIVE QUADRANT 1 2 3 4 (RE)ORIENT DEGREES -5 5 -15 15 -30 30 -45 45 -90 90 -180 180 CLEAR QUADRANT 1 2 3 4 SAVE SAVE NEW SAVE

Figure 34: Orientation Screen before NEW SAVE

3.4.3 ROOF

The roof operation is basically a menu selection process. For reasons explained in Chapter 2 a choice of roof construction types is presented to the user for selection. When the command ROOF is picked the Graphics Area fills with

roof description items and a list of twelve construction types. The number 20 strip message (PICK RCCF CONSTRUCTION TYPE NUMBER, OR (RETURN)) then prompts for selection from the list or to return to the basic EDECT screen and primary menu (Figure 35).


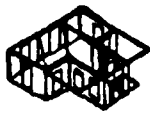
		1=48 FT			NAME: 2 MACROCLIMATE: 8-PRESHG OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:														
FOOTPRINT		SOUTHWEST VIEW																	
PICK ROOF CONSTRUCTION TYPE NUMBER, OR (RETURN)																			
ROOF TYPE: PITCHED w/ CATHEDRAL CEILING CURRENT CONSTRUCTION: 2 AVAILABLE ROOF CONSTRUCTION TYPES: <table border="0"> <tr> <td>1. 1 RIGID INSULATION, 1 WOOD.</td> <td>8. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.</td> </tr> <tr> <td>2. 2 RIGID INSULATION, 2 WOOD.</td> <td>9. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE.</td> </tr> <tr> <td>3. 1 RIGID INSULATION, 1 CONCRETE.</td> <td>10. BUILT-UP ROOF, 4 RIGID INSULATION, 4 CONCRETE, 1/2 GYP BOARD.</td> </tr> <tr> <td>4. 2 RIGID INSULATION, 2 CONCRETE.</td> <td>11. BUILT-UP ROOF, 4 CELLULAR GLASS INSULATION, 4 CONCRETE, 1/2 GYP BOARD.</td> </tr> <tr> <td>5. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE, AIR SPACE, 1/2 GYP BOARD.</td> <td>12. BUILT-UP ROOF, 8 CORK BOARD, 4 CONCRETE, 1/2 GYP BOARD.</td> </tr> <tr> <td>6. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE, AIR SPACE, 1/2 GYP BOARD.</td> <td></td> </tr> <tr> <td>7. BUILT-UP ROOF, 4 CONCRETE, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.</td> <td></td> </tr> </table>						1. 1 RIGID INSULATION, 1 WOOD.	8. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.	2. 2 RIGID INSULATION, 2 WOOD.	9. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE.	3. 1 RIGID INSULATION, 1 CONCRETE.	10. BUILT-UP ROOF, 4 RIGID INSULATION, 4 CONCRETE, 1/2 GYP BOARD.	4. 2 RIGID INSULATION, 2 CONCRETE.	11. BUILT-UP ROOF, 4 CELLULAR GLASS INSULATION, 4 CONCRETE, 1/2 GYP BOARD.	5. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE, AIR SPACE, 1/2 GYP BOARD.	12. BUILT-UP ROOF, 8 CORK BOARD, 4 CONCRETE, 1/2 GYP BOARD.	6. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE, AIR SPACE, 1/2 GYP BOARD.		7. BUILT-UP ROOF, 4 CONCRETE, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.	
1. 1 RIGID INSULATION, 1 WOOD.	8. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.																		
2. 2 RIGID INSULATION, 2 WOOD.	9. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE.																		
3. 1 RIGID INSULATION, 1 CONCRETE.	10. BUILT-UP ROOF, 4 RIGID INSULATION, 4 CONCRETE, 1/2 GYP BOARD.																		
4. 2 RIGID INSULATION, 2 CONCRETE.	11. BUILT-UP ROOF, 4 CELLULAR GLASS INSULATION, 4 CONCRETE, 1/2 GYP BOARD.																		
5. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 2 CONCRETE, AIR SPACE, 1/2 GYP BOARD.	12. BUILT-UP ROOF, 8 CORK BOARD, 4 CONCRETE, 1/2 GYP BOARD.																		
6. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION, 4 CONCRETE, AIR SPACE, 1/2 GYP BOARD.																			
7. BUILT-UP ROOF, 4 CONCRETE, 2 CELLULAR GLASS INSULATION, 2 CONCRETE.																			
OBJECT(S) READ FROM DISK LIST/SELECT DELETE SAVE TO DISK (RED) DEFINE MACROCLIMATE ORIENTATION ROOF WALL FLOOR WINDOW/DOOR OVERHANG BLDG. SYSTEMS																			
ANALYZE GRAPHICAL NUMERICAL																			
IMPROVEMENTS P VS. A N. PENETRATION S. PENETRATION																			
COMPARE																			
<div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; text-align: center; line-height: 40px; margin: 0 auto;">STOP</div>																			

Figure 35: Roof Selection Screen

The top roof descriptor identifies the roof type as:

1. Fitted w/ Suspended Ceiling (ARCHIMODOS Type 1)
2. Pitched w/ Cathedral Ceiling (ARCHIFCLCS Type 2)

or 3. Flat w/ Suspended Ceiling.

The type of roof determines how much roof area is calculated as affecting interior heat gain and how much interior volume is conditioned air volume. Since ceilings are assumed to be (and economically should be) the thermal barrier (insulated) their roof area is determined as being equal to the area of the footprint. The volume is roof area times exterior wall height (see Chapter 5 calculations). Calculations for roofs with roofs with suspended ceilings however must take into account the true roof area and interior volume (25).

The next descriptor indicates the construction type as currently defined. If no definition has been made it will be blank.

To make an initial roof construction type definition the user picks the number of type wanted, the numbers being light pen activated. If the total thickness of the type selected is less than or equal to current type's thickness the current construction descriptor will be updated with the construction type selected. Otherwise, strip message no. 21 (CURRENT ROOF THICKNESS IS LESS THAN CONSTRUCTION SELECTED. MODIFY? (Y) (N)) will ask if roof thickness should be modified. Picking Y (=yes) will replace the current with the new while N (=no) does nothing except return the original strip message no. 20 (PICK ROOF CONSTRUCTION TYPE NUMBER, OR (RETURN)). Roof construction type initially defaults to number 2.

To return to the basic screen and active primary menu the user picks RETURN in the strip message block. This also registers the current roof construction type in session memory. In the example, roof construction type 2 was chosen.

3.4.4 WALL

Wall construction type definition is similar to the menu selection course for roofs. Picking WALL brings up a list of 19 wall construction types, a current object footprint, the wall secondary menu and strip message/prompt no. 22. Any wall that has been previously defined will have the construction type number superimposed on it (Figure 36). To begin wall definition the number of the construction type desired is picked. A selection indicator (>) appears next to the number selected and updated for subsequent choices. To assign a construction type to a wall the user then picks the wall from the enlarged footprint. All walls on the enlarged footprint are light pen activated. Similar to roofs, any increases in wall thickness due to type selection

must be first approved by the user through strip message no. 23 (CURRENT WALL THICKNESS IS LESS THAN CONSTRUCTION SELECTED. MODIFY? (Y) (N)). Default construction type for walls is number 2.

		NAME: 2 MACROCLIMATE: 8-PRESNO OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:				
FOOTPRINT SOUTHWEST VIEW		PICK WALL CONSTRUCTION TYPE -> WALL SEGMENT OR MENU COMMAND.				
<table border="0"> <tr> <td data-bbox="371 693 826 1554"> <p>AVAILABLE WALL CONSTRUCTION TYPES:</p> <ol style="list-style-type: none"> 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 AIR SPACE. 1/2 GYP BOARD. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 GYP BOARD. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 PANELING. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 7/8 WOOD FURRING. 1/2 PANELING. 1 STUCCO. 6 CONCRETE. 1 GYP BOARD 1/2 CEMENT PLASTER. 4 FILLED CONCRETE BLOCK. AIRSPACE. 4 FILLED CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 CONCRETE BLOCK. AIRSPACE. 4 CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 HOLLOW TERRA COTTA BLOCKS. AIRSPACE. 1/2 CEMENT PLASTER. 6 SOLID BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 6 HOLLOW BRICK. 1 X 2 FURRING. 1/2 GYP BOARD. 6 HOLLOW BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 8 BRICK/CONC. BLOCK. 1 X 2 FURRING. 1/2 GYP BOARD. </td> <td data-bbox="826 693 1313 1554"> </td> <td data-bbox="1313 693 1495 1554"> <p>MAIN MENU SELECT ALL</p> </td> </tr> </table>				<p>AVAILABLE WALL CONSTRUCTION TYPES:</p> <ol style="list-style-type: none"> 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 AIR SPACE. 1/2 GYP BOARD. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 GYP BOARD. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 PANELING. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 7/8 WOOD FURRING. 1/2 PANELING. 1 STUCCO. 6 CONCRETE. 1 GYP BOARD 1/2 CEMENT PLASTER. 4 FILLED CONCRETE BLOCK. AIRSPACE. 4 FILLED CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 CONCRETE BLOCK. AIRSPACE. 4 CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 HOLLOW TERRA COTTA BLOCKS. AIRSPACE. 1/2 CEMENT PLASTER. 6 SOLID BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 6 HOLLOW BRICK. 1 X 2 FURRING. 1/2 GYP BOARD. 6 HOLLOW BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 8 BRICK/CONC. BLOCK. 1 X 2 FURRING. 1/2 GYP BOARD. 		<p>MAIN MENU SELECT ALL</p>
<p>AVAILABLE WALL CONSTRUCTION TYPES:</p> <ol style="list-style-type: none"> 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 AIR SPACE. 1/2 GYP BOARD. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 GYP BOARD. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 PANELING. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 7/8 WOOD FURRING. 1/2 PANELING. 1 STUCCO. 6 CONCRETE. 1 GYP BOARD 1/2 CEMENT PLASTER. 4 FILLED CONCRETE BLOCK. AIRSPACE. 4 FILLED CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 CONCRETE BLOCK. AIRSPACE. 4 CONCRETE BLOCK. 1/2 CEMENT PLASTER. 1/2 CEMENT PLASTER. 4 HOLLOW TERRA COTTA BLOCKS. AIRSPACE. 1/2 CEMENT PLASTER. 6 SOLID BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 6 HOLLOW BRICK. 1 X 2 FURRING. 1/2 GYP BOARD. 6 HOLLOW BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD. 8 BRICK/CONC. BLOCK. 1 X 2 FURRING. 1/2 GYP BOARD. 		<p>MAIN MENU SELECT ALL</p>				

Figure 36: Wall Selection Screen

If all object walls are to be of one construction type the command **SELECT ALL** may be picked after selecting the type. In the example all walls have been **SELECT ALL** defined as type 3.

MAIN MENU is picked to register definitions appearing on the footprint and restore the **SELECT** basic screen/primary menu.

3.4.5 FLOOR

Since all models analyzed by EDECT are assumed to be slab-on-grade construction there will be no appreciable heat transfer through the floor. Any contribution to the heating/cooling loads from the floor then will come from the floor slab perimeter. Standard practice with floor slabs, in fact required by code in some states, is to insulate the slab perimeter to minimize what floor heat gain and loss there might be (22). With this in mind EDECT has no user interaction for the FLOOR command. Instead, when the user picks the command FLOOR an informative message about the perimeter insulation appears in the graphics area (Figure 37).



FOR COMPARISON PURPOSES, ALL FLOORS ARE CONSIDERED SLAB ON GRADE WITH PERIMETER INSULATION AND A HEAT LOSS RATE OF .65 BTU/HR * FT * DEGREE F.

Figure 37: Floor Message

The same perimeter insulation is used for all objects so fair comparisons between different objects can be made. The U-value chosen is enforced by several building codes and an economical choice.

3.4.6 WINDOW/DOOR

To manipulate openings (windows and doors) EDECT uses the Window/Door Secondary Menu and two different screens in the Graphics Area. When the command WINDOW/DOOR is picked the secondary menu, initial graphic area screen and strip message no. 9 (PICK WALL FROM ENLARGED FOOTPRINT OR MAIN MENU TO RETURN) are brought up (Figure 38).

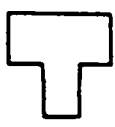

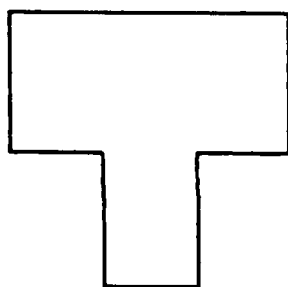








		NAME: 2 MACROCLIMATE: 8-PRESNO OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT SOUTHWEST VIEW		PICK WALL FROM ENLARGED FOOTPRINT OR MAIN MENU TO RETURN	
1		MAIN MENU OPENING ADD DELETE   SHAPE     TRANS  	
2	WINDOW/DOOR TYPES CONSTRUCTION DOUBLE-HUNG WOOD FRAME WINDOW 1 NON-WEATHERSTRIPPED 2 WEATHERSTRIPPED DOUBLE-HUNG METAL FRAME WINDOW 3 NON-WEATHERSTRIPPED 4 WEATHERSTRIPPED ROLLED STEEL FRAME GLAZED WINDOW/DOOR 5 INDUSTRIAL, PIVOTED (OR AWNING) 6 RESIDENTIAL, CASMENT (OR HINGES) WOOD OR METAL DOOR 7 NON-WEATHERSTRIPPED 8 WEATHERSTRIPPED GLAZING 5 SINGLE 8 DOUBLE 7 TRIPLE		DEFINE TYPE SELECT 1 2 CLEAR 1 2

Figure 38: Beginning (Basic) Window/Door Screen

The footprint in the upper right quadrant is in the same proportion to its window as the Object Data Box footprint is to its window. All walls on the larger footprint are light

pen active. The lower right quadrant contains the opening types definition menu which is divided into two parts; construction choices and glazing choices. The numbers next to the construction types and the letters S, D, and T next to the glazing types are also light pen activated.

To begin working openings, the wall on which openings will be worked must be picked. Note that a wall does not have to have openings before being picked. Before a wall is picked all commands are in a temporarily inactive state. When a wall is picked the Graphic Area is replaced with an elevation of that wall, scale marker, scale change command, and strip message no. 10 (SELECT OPENING->OPERATION, (RETURN), OR SAVE IN WINDOW 1 2) comes up (Figure 39).

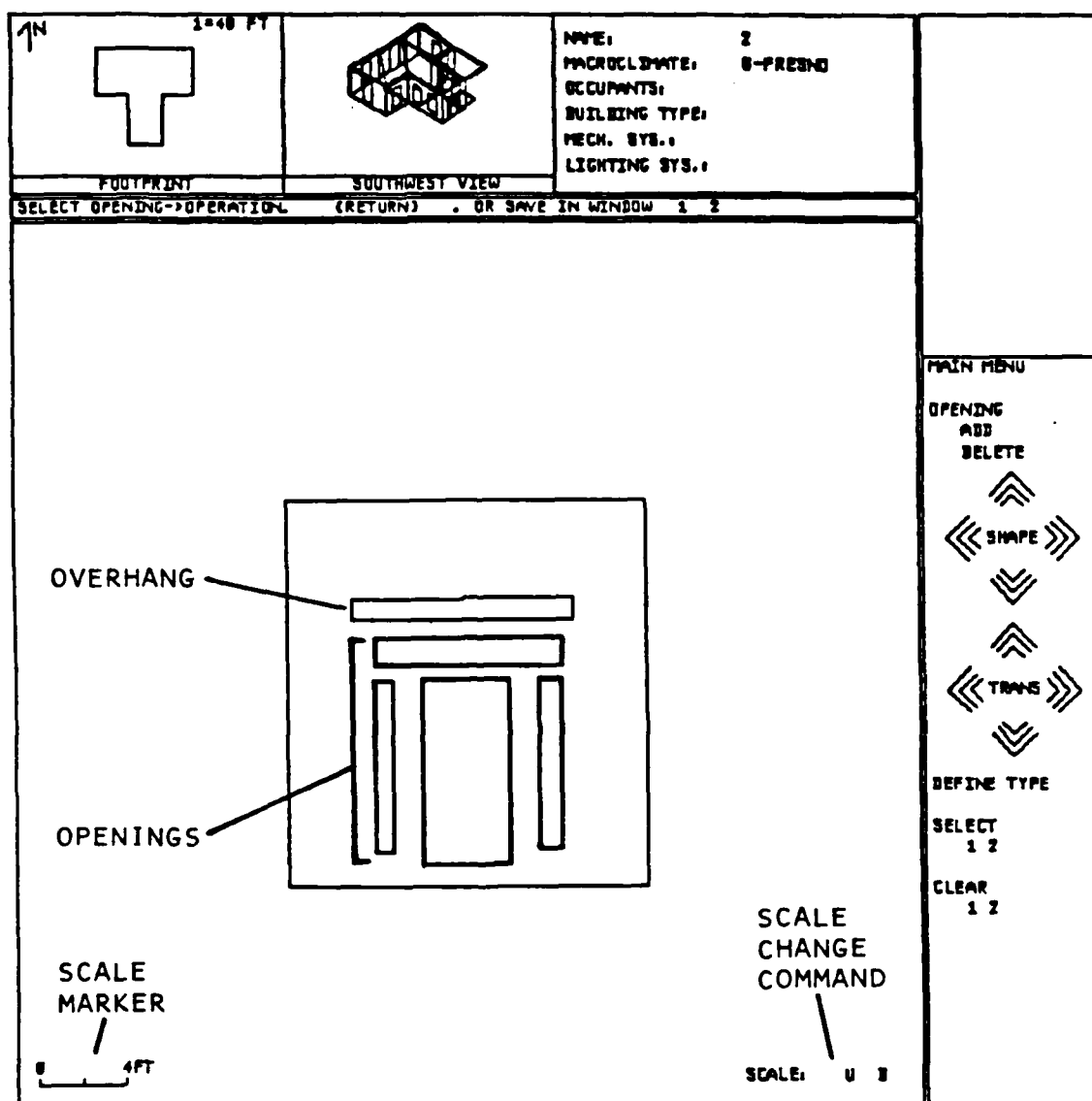


Figure 39: Second Window/Door (Elevation) Screen

The elevation appears at a scale proportional to the Graphics Area as the footprints - both in the Object Data Box and the previous screen - are to their respective windows. The elevation can be scaled up or down by picking U (up) or D (down) from the Scale Change Command. If there are any overhangs on the wall they are differentiated from openings by a lighter intensity on the 3251. Openings are light pen activated. From this screen the user may, at any time, return to the previous screen by picking RETURN in the strip message box. Also in this screen only the commands ADD, DELETE and the movement disks SHAPE and TRANS are active.

Before covering EDECT's opening sizing and positioning capabilities, a brief explanation on the movement disks is warranted.

Movement Disks Description

Used in both opening and overhang operations, the movement disk is an important EDECT - user interaction device. Graphically it appears as a pattern of 12 varying sized arrowheads arranged around a command mnemonic (Figure 40).

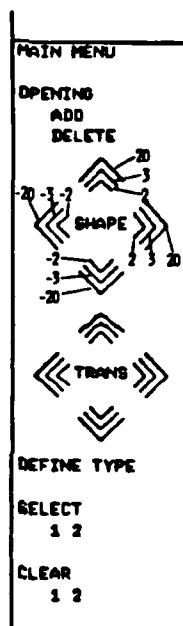


Figure 40: Movement Disks (Window/Door Secondary Menu)

Each arrowhead is light pen activated and represents the number of inches of command mnemonic movement. For example, the smallest arrowhead pointing up from the SHAPE command will elongate the active opening by 2 inches in the vertical, and the largest arrowhead pointing to the left widens an opening by 20 inches in the horizontal. All movement disk arrowheads throughout EDECT symbolize the same inch quantities shown in Figure 40. Arrowheads pointing down or to the left stand for negative quantities. The nature of each movement disk command will be explained individually.

Shaping and Moving Openings

To shape or move an opening on an elevation the user must first pick the opening to make it active. There can be no more than one opening active at a time and the user can activate any opening on the elevation screen at any time.

The active opening is identified by a higher intensity than any other opening. Activating one opening deactivates any previously active openings. The commands available to operate on an active opening are DELETE, SHAPE and TRANS. DELETE erases the active opening, SHAPE changes the size per arrowhead picked, and TRANS moves the opening in the direction and increment of the arrowhead picked. The SHAPE transformations operate on a box-scale principle where the lower left hand corner of the opening is fixed and top (for up and down arrowheads) or left (for left and right arrowheads) opening segment moves in the increment picked.

The following figure shows the example elevation after the transom like opening (assuming the largest opening is a door) has been redefined with the movement disks. After activation it was reshaped by two (2) -20 inch left SHAPE arrowhead picks followed by a 20 inch and a 2 inch right SHAPE arrowhead picks (Figure 41).

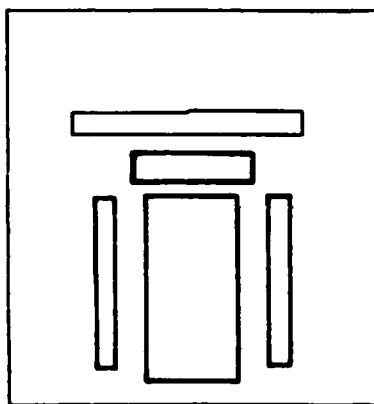


Figure 41: Opening Shaping and Translation Example

The ADD command facilitates adding an opening to a wall. When the scaled elevation screen comes to view the ADD command is activated. Picking ADD causes a 24" x 24" opening to appear below and centered to the elevation. When an opening is added it becomes the active opening and can be operated on like any other active opening. In the following example figure the ADD command was picked and the new opening was translated up to a position above the overhang (Figure 42).

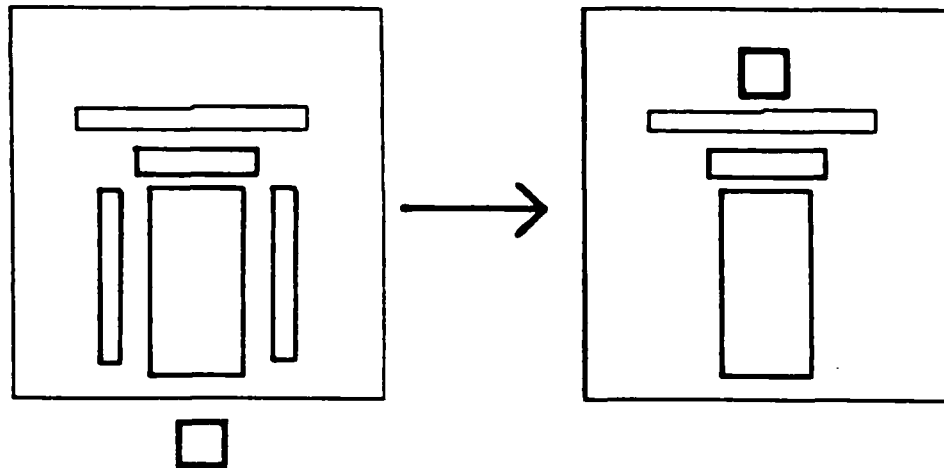


Figure 42: Opening Addition and Translation Example

Returning to the Basic Window/Door Screen

To return to the basic window/door screen the user has two basic options; return without saving the elevation screen or save the elevation screen in one of two beginning screen windows. To return without saving, RETURN in the strip message box is picked and the basic screen reappears as it was before the elevation screen was brought up.

To save an elevation for further opening operations the user picks either 1 or 2 in the strip message box. Picking 1 will save the elevation in the upper left window of the window/door basic screen and 2 will save to the lower left window. A pound sign (#) behind the 1 or 2 means the window already has an image and saving to it will erase that image. Before saving EDECT checks for illegal opening conditions. An illegal opening condition is one where:

- a) two or more openings overlap
- b) an opening extends below the interior floor elevation (assumed to be 10" above grade).
- c) an opening extends above the ceiling (top of wall minus roof construction type thickness).
- d) an opening extends beyond the side segments of an elevation.

Any violation of the above conditions results in strip message no. 13 (ILLEGAL OPENING/CONDITICN EXISTS. FRUS-TRATED? YOU MAY (RETURN)) being issued which allows the user to return to the basic screen by picking RETURN. The

user may also attempt to eliminate the illegal condition by deleting, reshaping, or translating openings.

In the following figure the example elevation from above was saved to window 1. The number 8 inside the largest opening of window 1 indicates that opening was previously defined as door construction type 8. The number 1 on the footprint segment indicates that segment corresponds to the wall elevation in window 1. (Figure 43).

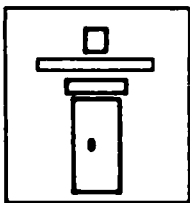
PICK WALL FROM ENLARGED FOOTPRINT OR MAIN MENU TO RETURN																																					
1																																					
2	<table border="1"> <thead> <tr> <th colspan="2">WINDOW/DOOR TYPES</th> </tr> </thead> <tbody> <tr> <td colspan="2">CONSTRUCTION</td> </tr> <tr> <td colspan="2">DOUBLE-HUNG WOOD FRAME WINDOW</td> </tr> <tr> <td>1</td> <td>NON-WEATHERSTRIPPED</td> </tr> <tr> <td>2</td> <td>WEATHERSTRIPPED</td> </tr> <tr> <td colspan="2">DOUBLE-HUNG METAL FRAME WINDOW</td> </tr> <tr> <td>3</td> <td>NON-WEATHERSTRIPPED</td> </tr> <tr> <td>4</td> <td>WEATHERSTRIPPED</td> </tr> <tr> <td colspan="2">ROLLED STEEL FRAME GLAZED WINDOW/DOOR</td> </tr> <tr> <td>5</td> <td>INDUSTRIAL, PIVOTED (OR AWNING)</td> </tr> <tr> <td>6</td> <td>RESIDENTIAL, CASEMENT (OR HINGED)</td> </tr> <tr> <td colspan="2">WOOD OR METAL DOOR</td> </tr> <tr> <td>7</td> <td>NON-WEATHERSTRIPPED</td> </tr> <tr> <td>8</td> <td>WEATHERSTRIPPED</td> </tr> <tr> <td colspan="2">GLAZING</td> </tr> <tr> <td>9</td> <td>SINGLE</td> </tr> <tr> <td>D</td> <td>DOUBLE</td> </tr> <tr> <td>T</td> <td>TRIPLE</td> </tr> </tbody> </table>	WINDOW/DOOR TYPES		CONSTRUCTION		DOUBLE-HUNG WOOD FRAME WINDOW		1	NON-WEATHERSTRIPPED	2	WEATHERSTRIPPED	DOUBLE-HUNG METAL FRAME WINDOW		3	NON-WEATHERSTRIPPED	4	WEATHERSTRIPPED	ROLLED STEEL FRAME GLAZED WINDOW/DOOR		5	INDUSTRIAL, PIVOTED (OR AWNING)	6	RESIDENTIAL, CASEMENT (OR HINGED)	WOOD OR METAL DOOR		7	NON-WEATHERSTRIPPED	8	WEATHERSTRIPPED	GLAZING		9	SINGLE	D	DOUBLE	T	TRIPLE
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8	WEATHERSTRIPPED																																				
GLAZING																																					
9	SINGLE																																				
D	DOUBLE																																				
T	TRIPLE																																				

Figure 43: Basic Window/Door Screen w/ Saved Elevation

Defining Opening Construction and Glazing Types

With an elevation in window 1 and/or 2 of the basic screen, opening construction type and glazing (re)definition can occur. With window 1 and/or 2 filled the active commands are MAIN MENU, DEFINE TYPE, SELECT, and CLEAR. The enlarged footprint segments, elevation openings, and window/door type

The words **DEFINED**, **UNDEFINED** and **RETURN** are light pen active. Picking **DEFINED** makes all previously defined object openings the same as the active opening while **UNDEFINED** copies the active window's definition onto all undefined openings. **RETURN** is picked to leave the construction/glazing definition process and reactivate the footprint and commands **SELECT** and **CLEAR**. The next figure illustrates this global definition technique.

				NAME: 2 MACROCLIMATE: 6-PRESNO OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:	
FOOTPRINT		SOUTHWEST VIEW			
PICK WALL FROM ENLARGED FOOTPRINT OR MAIN MENU TO RETURN					
1		2		MAIN MENU OPENING ADD DELETE << SHAPE >> << TRANS >> REFINE TYPE SELECT 1 2 CLEAR 1 2	
2		WINDOW/DOOR TYPES CONSTRUCTION DOUBLE-HUNG WOOD FRAME WINDOW 1 NON-WEATHERSTRIPPED 2 WEATHERSTRIPPED DOUBLE-HUNG METAL FRAME WINDOW 3 NON-WEATHERSTRIPPED 4 WEATHERSTRIPPED ROLLED STEEL FRAME GLAZED WINDOW/DOOR 5 INDUSTRIAL PIVOTED (OR AWNING) 6 RESIDENTIAL CASEMENT (OR HINGES) WOOD OR METAL DOOR 7 NON-WEATHERSTRIPPED 8 WEATHERSTRIPPED GLAZING 9 SINGLE 0 DOUBLE T TRIPLE			

Figure 45: Global Copy Illustration

When the transom opening in window 1 was active **UNDEFINED** was picked after defining the transom as type '6S'. The elevation in window 2 (from the east side of the object)

illustrates the four openings of that elevation were previously not defined and received the same definition as the active opening (Figure 45).

Selecting An Opening Definition

When the user wants to copy either window 1 or 2's elevation onto the object the number 1 or 2 (corresponding to the windows) under the command SELECT is picked. Before making the copy EDECT will verify the user's intent with strip message no. 12 (PERMANENT OPENINGS WILL BE CHANGED!! CONTINUE? (Y) (N)). Making a successful copy will update the isometric view in the object data box and store the window/door types in memory. The window from which the elevation is copied is also cleared. To clear a window without saving its contents the 1 or 2 under the command CLEAR can be picked.

To terminate opening definition and return the primary menu MAIN MENU is picked.

3.4.7 OVERHANG

Adding, deleting, sizing and positioning overhangs are done by picking this command. When the command OVERHANG is picked from the primary menu an object isometric is brought up in the Graphics Area, the Overhang Secondary Menu appears, and strip message no. 18 (TO ADD OVERHANG, PICK WALL BOTTOM. ELSE PICK OVERHANG -> OPERATION) is issued (Figure 46). The isometric image is the same view and proportion as the object data box view.

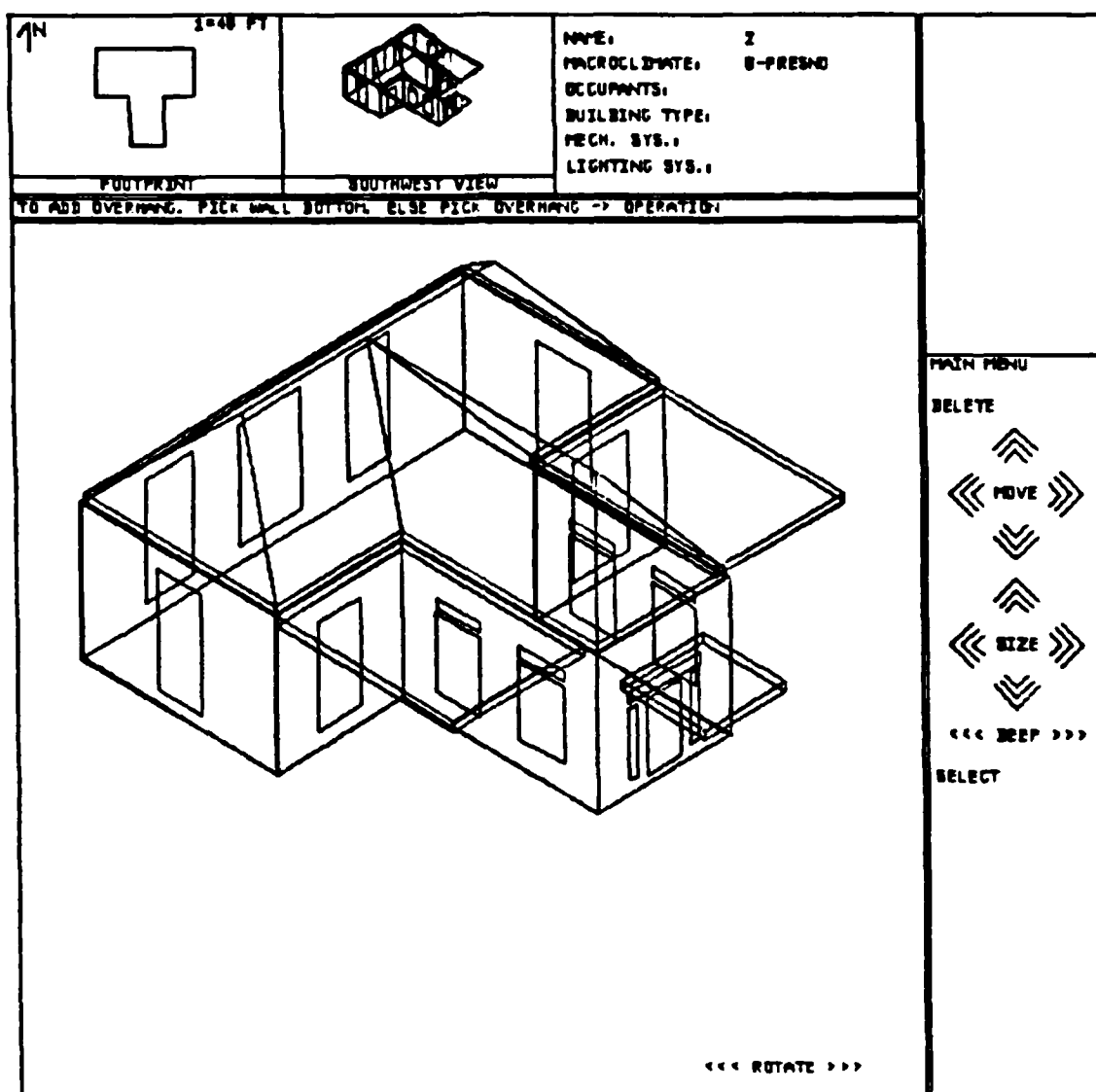


Figure 46: Example Screen After Picking CVERHANG

The isometric view can be changed at anytime during overhang (re)definition using the ROTATE command in the bottom right corner of the Graphic Area. Similar in concept to the movement disks, the arrowheads on either side of ROTATE represent an incremental degree of rotation the isometric view will be rotated at when picked. The increments are:

< < < ROTATE > > >
-45 -15 -5 5 15 45 - degrees

where positive numbers are clockwise rotations and negative counterclockwise. The following figure illustrates the example object being rotated a positive 90 degrees in increments of 15 degrees (Figure 47).

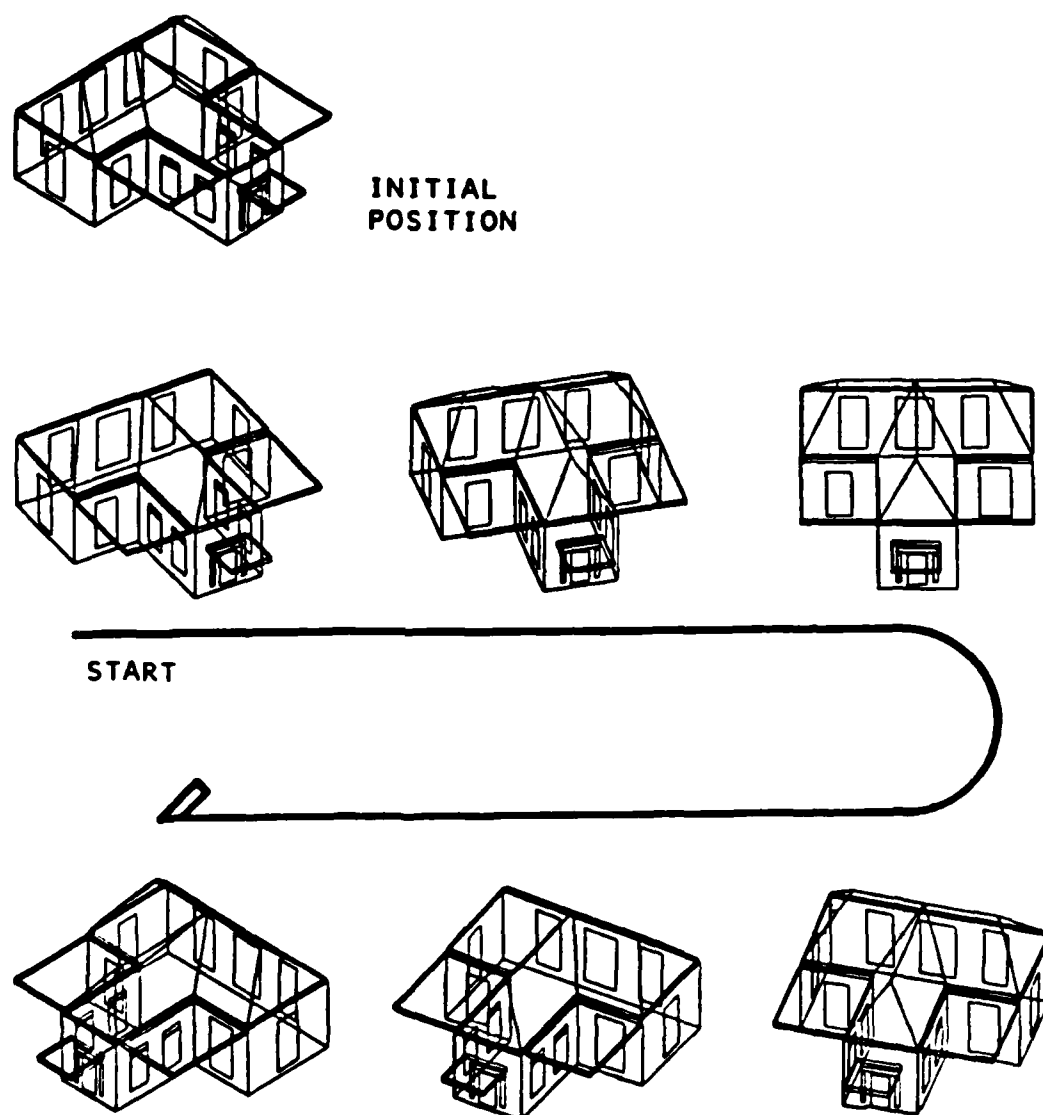


Figure 47: Example Rotation Sequence

Adding and Deleting Overhangs

The example object in Figure 46 came up on the screen with previously defined overhangs. To add an overhang to a wall the user simply picks the base (bottom segment) of the wall. All wall bases of the isometric image are activated with the

light pen. When the base is picked an overhang of default size emerges on the wall. Default overhang size is 12 inches deep x 24 inches thick x the width of the wall; depth being the distance an overhang extends away from a wall, thickness the vertical distance between top and bottom overhang faces, and width the horizontal distance between overhang side faces. Default position for a newly added overhang is with top face of the overhang even with the top of the wall. The backface of any overhang is coplanar to the plane of the wall picked to have the overhang.

When an overhang is added to a wall it automatically becomes the active overhang. An active overhang is indicated by a higher line intensity than any other overhang. All inactive overhangs are light pen sensitive and if one is picked it becomes the active overhang. The MOVE, SIZE and DEEP arrowheads as well as the the command SELECT are active only when there is an active overhang. Only one overhang can be active at a time. A wall can have multiple overhangs, too.

Deleting an overhang from the isometric picture is done by first making the subject overhang active then picking the command DELETE. This deletion does not affect the current object unless the command SELECT is picked (see selecting information below).

Sizing and Positioning Overhangs

The movement disks/arrowheads around the command mnemonics MOVE, SIZE, and DEEP control an active overhangs position (on its wall plane) and size. The MOVE and SIZE arrowheads operate with the same inch increments as the opening movement disk arrowheads (see Movement Disks Description in subsection 3.4.6). The DEEP arrowheads are incremented thus:

< < < DEEP > > >
 -20 -15 -5 5 15 45 - inches

where a positive number extends the front overhang face away from the wall and a negative number contracts the front face towards the wall.

The following figure shows an overhang that has been added to the example object's western-most wall. The labels indicate the direction in which the arrowheads manipulate the overhang. MOVE adjusts overhang wall position and SHAPE changes the active overhang's width and thickness (Figure 48).

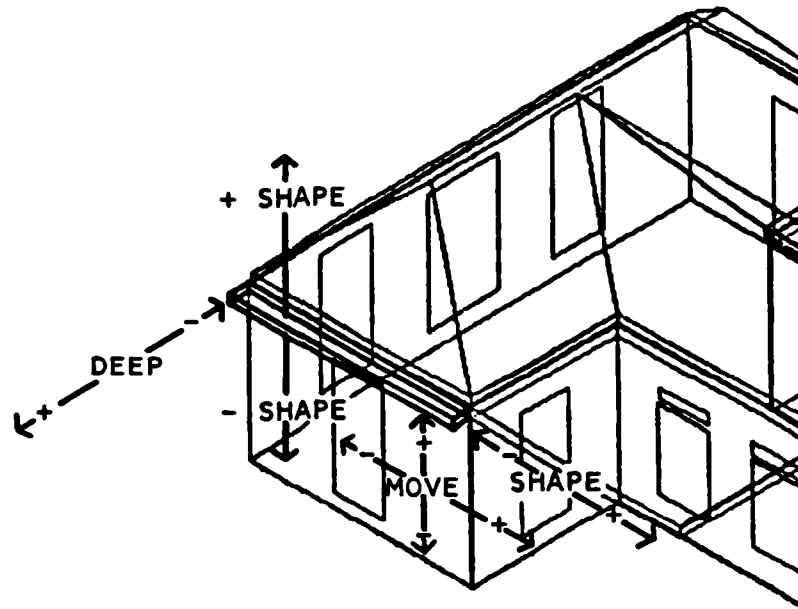


Figure 48: Overhang Manipulation Illustration

Selecting an Overhang Arrangement

Whenever the user wishes to record the overhang condition as it appears in the Graphics Area, the command **SELECT** is used. Picking **SELECT** records the overhang state to session memory and reflects the same state in the Object Data Box view, after user intent verification by strip message no. 19 (PERMANENT OVERHANGS WILL CHANGE!!! CONTINUE? (Y) (N)). The current object's overhangs will be updated as often as **SELECT** is picked and **SELECT** can be picked more than once before returning to the primary menu. Returning to the primary menu is done by picking command **MAIN MENU**.

The next figure is the result of manipulating the active overhang from Figure 48 by +20 inches **DEEP**, +9 inches thickness (**SIZE**), and -9 inches **MOVE** down. The large overhangs on either side of the entry way have also been deleted. Picking **SELECT** after these changes would reflect the changes in the current object's session data and the Southwest View in the data box above would be regenerated to appear as the large isometric view appears (Figure 49).

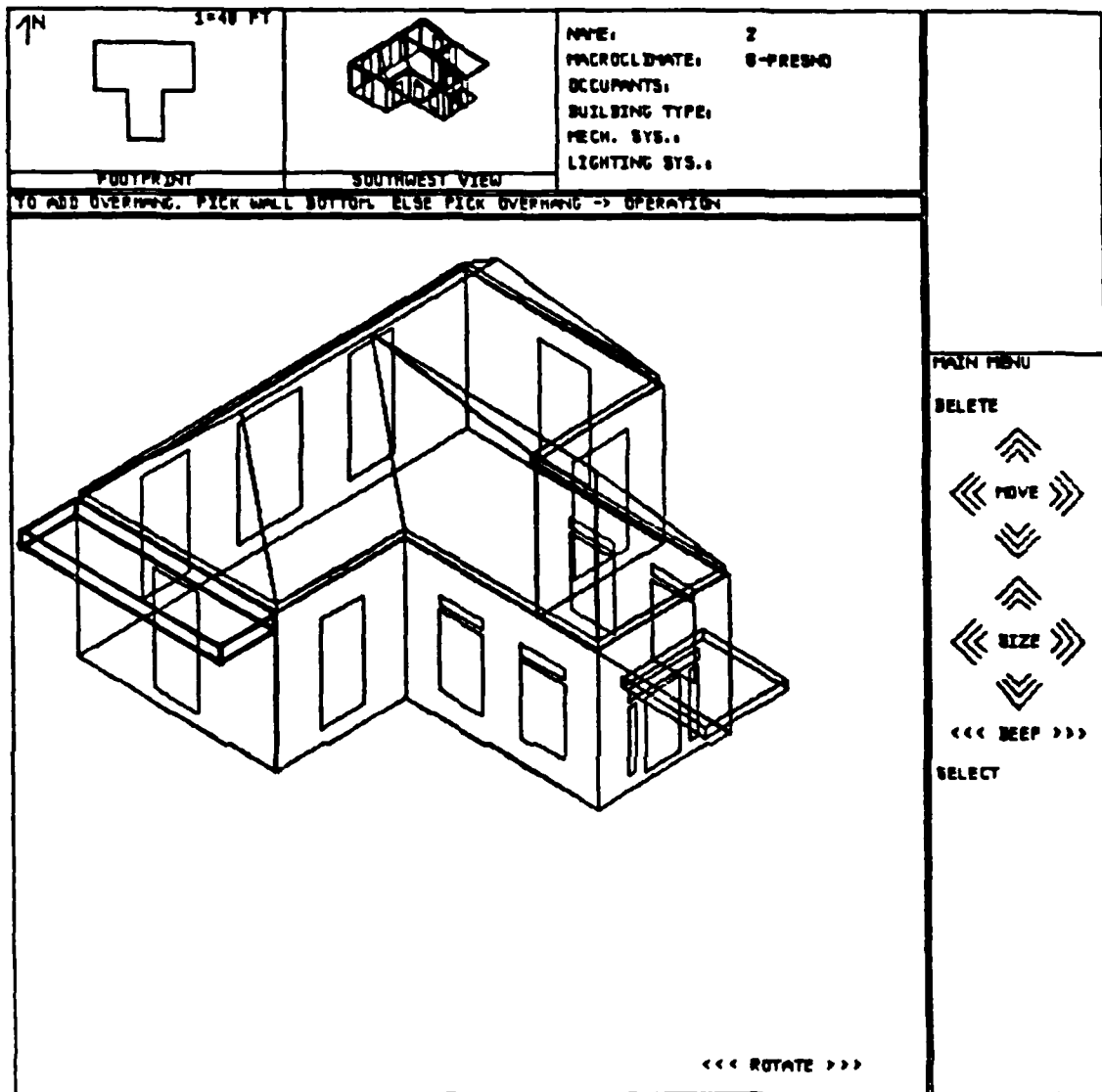


Figure 49: Example Object After Overhang (Re)definition

3.4.8 BLDG. SYSTEMS

This command is a composite command in that it represents four distinct (re)definition procedures which define an object's building type, number of occupants, mechanical system and lighting system. Picking the primary command BLDG. SYSTEMS brings up four definition windows in the Graphics Area and strip message no. 17 (PICK SELECTIONS. TO REGISTER SELECTIONS: (RETURN)). The four definition windows, one per definition procedure, occupy equal area quadrants of the Graphics Area and are labeled BUILDING TYPE, OCCUPANTS, MECHANICAL SYSTEM, and LIGHTING SYSTEM (Figure 50).

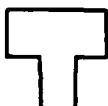

				NAME: Z MACROCLIMATE: B-PRESNO OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:																																					
FOOTPRINT		SOUTHWEST VIEW																																							
PICK SELECTIONS. TO REGISTER SELECTIONS: (RETURN)																																									
BUILDING TYPE: CLINIC COMMUNITY CENTER GYMNASIUM HOTEL/MOTEL APARTMENT > RESIDENTIAL OFFICE RETAIL WAREHOUSE			OCCUPANTS: <table border="1"> <thead> <tr> <th colspan="6">(PICK)</th> </tr> <tr> <th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th> </tr> </thead> <tbody> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td> </tr> <tr> <td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td> </tr> <tr> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> </tr> <tr> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> </tr> </tbody> </table> TOTAL: 3 (RESET)			(PICK)						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
(PICK)																																									
1	2	3	4	5	6																																				
7	8	9	10	11	12																																				
13	14	15	16	17	18																																				
19	20	21	22	23	24																																				
25	26	27	28	29	30																																				
MECHANICAL SYSTEM: OIL-FIRED > GAS-FIRED STEAM CONVERTER RESISTANCE BOIL RESISTANCE STRIP WATER HEAT PUMP AIR HEAT PUMP			LIGHTING SYSTEM: > INCANDESCENT FLUORESCENT MERCURY VAPOR METAL HALIDE HIGH PRES SODIUM																																						
OBJECT(S) READ FROM DISK LIST/SELECT DELETE SAVE TO DISK (RE)DEFINE MACROCLIMATE ORIENTATION ROOF WALL FLOOR WINDOW/DOOR OVERHANG BLDG. SYSTEMS																																									
ANALYZE GRAPHICAL NUMERICAL																																									
IMPROVEMENTS V. VS. A N. PENETRATION S. PENETRATION																																									
COMPARE																																									
<div style="border: 1px solid black; border-radius: 50%; width: 40px; height: 40px; text-align: center; line-height: 40px; margin: 0 auto;">STOP</div>																																									

Figure 50: Screen After Picking BLDG. SYSTEMS

During BLDG. SYSTEMS (re)definition all primary menu commands remain inactive. The active mnemonics are the menu types for building type, mechanical system, lighting system; the numbers in the occupant 'pick' pad, RESET in the occupant quadrant, and RETURN in the strip message box.

Selecting Building Type/Mechanical-Lighting Systems

Building type, mechanical system and lighting system are selected in a like manner: the user simply picks the menu item desired. Upon picking, a selection indicator (>) is placed to the left of the item. In Figure 50 the menu items RESIDENTIAL (building type), GAS-FIRED (mechanical system) and INCANDESCENT (lighting system) have been picked. Only one item per quadrant can be indicated as selected and further selections update the indicator.

Selecting Occupants

(Re)defining number of occupants requires a different procedure from the other three BLDG. SYSTEMS components. To establish occupant number the user picks the desired number from the 'pick' pad (enclosed numbers within the occupant quadrant). Picking more than one number has a cumulative effect on the total occupant number which is tallied next to the alphanumeric TOTAL: in the occupant quadrant. For example picking 16 -> 16 -> 2 in sequence would display 34 to the left of TOTAL:.

Picking RESET zeroes out the total number so the user can start over. In Figure 50, occupants have been defined at 5.

Registering Selections

When all the desired selections have been made the user may assign them to the current object by picking RETURN in the strip message box. This clears the Graphics Area and strip message box; lists the selections in the Object Data Box; and reactivates the primary menu. For analysis purposes, any BLDG. SYSTEM element that has not been user defined will default accordingly:

Building Type	- Office
Occupants	- 30
Mechanical System	- Resistance Strip
Lighting System	- Fluorescent

The following figure is the condition of the Object Data Box after the selections of Figure 50 were registered to the current object (Figure 51).

		NAME: 2 MACROCLIMATE: 8-PRESNO OCCUPANTS: 5 BUILDING TYPE: RESIDENTIAL MECH. SYS.: GAS-FIRED LIGHTING SYS.: INCANDESCENT
FOOTPRINT	SOUTHWEST VIEW	

Figure 51: Data Block after BLDG. SYSTEMS Registration

3.5 ANALYZE Commands Category

When the user is satisfied with the current object's definitions, or if (s)he wants to make an interim check on the current object's energy performance the two commands GRAPHICAL and NUMERICAL, in this category, are picked. A graphical and/or numerical analysis by EDECT is rapid and can be performed at any stage of the energy design and as often as desired. The current object design parameters, whether defaulted or user defined, at the time either analysis is called for are the ones used in the energy calculations. The next chapter elaborates those calculations.

3.5.1 GRAPHICAL

To obtain a graphical analysis on the current object the command GRAPHICAL is picked which results in the graph plot of object's envelope energy performance over a year's time at sampling points for the 15th of each month and every hour in a 24 hour period. Heat gain is plotted above the C plane frame and heat loss below (Figure 52). Interpretation of the graph is straight forward once the principles of subsection 2.7.8 - Graphical Analysis - are grasped.

After the plot is complete, all primary commands are active and the graph image stays in the Graphics Area until cleared by another command.

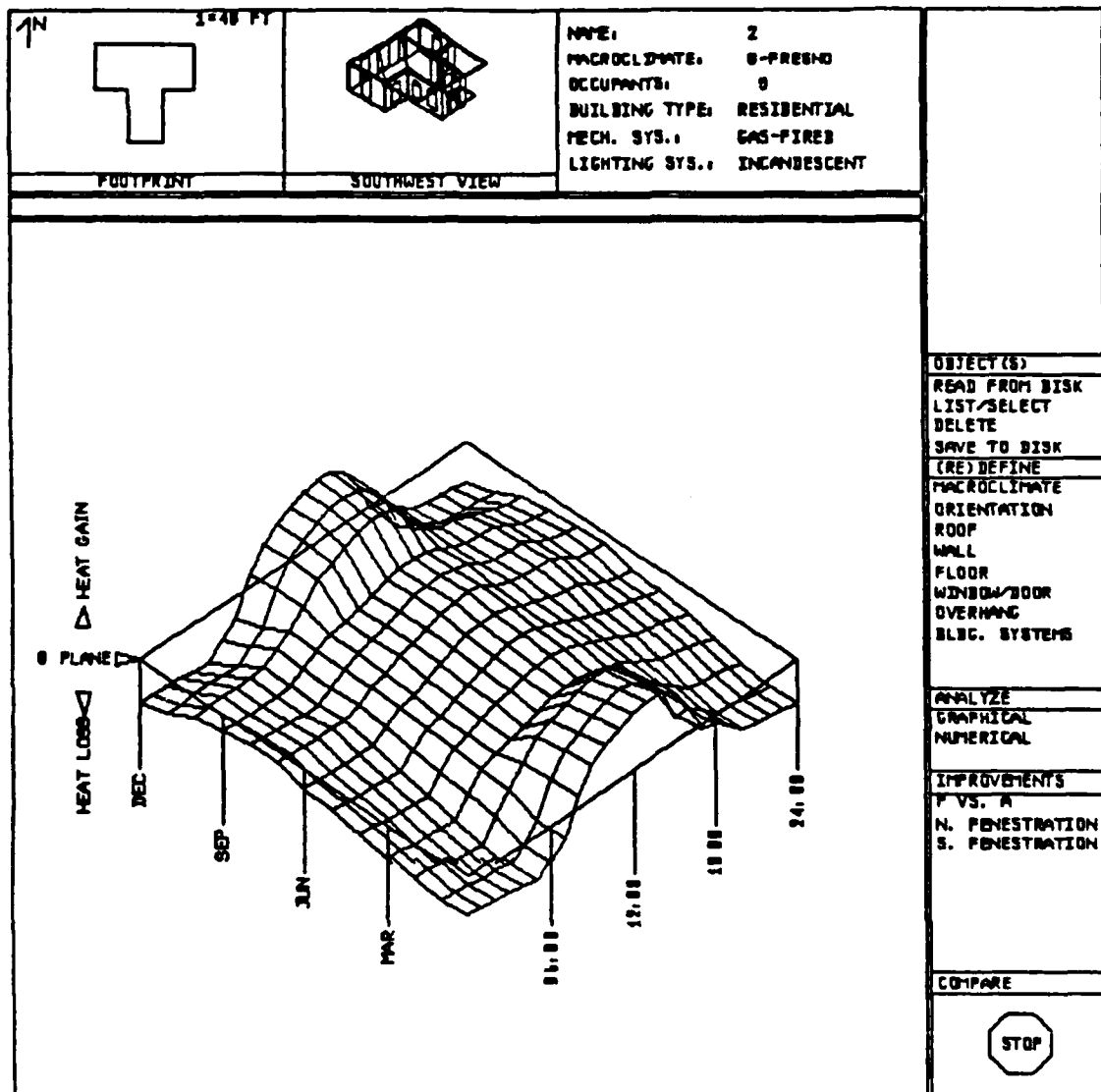


Figure 52: Screen After Picking GRAPHICAL

3.5.2 NUMERICAL

Picking the command **NUMERICAL** invokes **EDECT**'s energy analysis procedure which produces results in two forms: detailed and abbreviated. The detailed numerical analysis is formatted and appears on the 3279 display screen. Depending on the current object, several screens worth of detailed analysis forms will appear on the 3279. The user can wait for the 4341 operating system to cycle through the analysis screens - at a rate of one minute per full screen- or view each screen at his/her own rate. To move from one screen to the next the 3279 keyboard keys 'ALT' and 'FIELD MARK' are pressed at the same time. 'ALT' + 'CURSR SEL' also bring up the next screen. If the user wants to view a screen for more than one minute pressing the 'ENTER' key on the 3279 keyboard will hold the present screen until manually refreshed with the next screen. The user may also bypass the 3279 screen analysis by entering "HT" (for halt typing) on the 3279 keyboard before picking **NUMERICAL**. The 3279 monitor will then display nothing until "RT" (resume typing) is entered

When the detailed analysis is completed the abbreviated version comes up in the Graphics Area of the 3251 display (Figure 53).

Both the extended and summary energy use results are annual and in fact the annual energy summary is made up of key selections from the detailed analysis.

Along with the Annual Energy Use Summary strip message no. 26 (DO YOU WISH TO SAVE THE ANALYSIS TO DISK? (Y) (N)) is brought up asking the user if (s)he wishes to write the detailed annual energy analysis to disk. Picking Y (=yes) makes a copy of the extended analysis to disk storage (see Appendix C for details) while N (=no) only clears the strip message box. A pick of either Y or N leaves the Annual Energy Use Summary on the screen and reactivates the primary command menu, which was inactive since picking **NUMERICAL**.

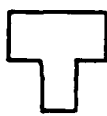


1N 	1=40 FT 	NAME: 2 MACROCLIMATE: 8-PRESNO OCCUPANTS: 0 BUILDING TYPE: RESIDENTIAL MECH. SYS.: GAS-FIRED LIGHTING SYS.: INCANDESCENT	
FOOTPRINT	SOUTHWEST VIEW		
DO YOU WISH TO SAVE THE ANALYSIS TO DISK? (Y) (N)			
<div data-bbox="569 703 1049 766"> ***** = ANNUAL ENERGY USE SUMMARY (MBTU) = ***** </div> <div data-bbox="586 808 1007 976"> TOTAL HEATING ENERGY USE: 71 TOTAL COOLING ENERGY USE: 419 DOMESTIC HOT WATER FUEL USE: 62 TOTAL CONNECTED ELECTRICAL LOAD: 183 ----- TOTAL ANNUAL ENERGY USE: 731 </div>			
OBJECT(S)			
READ FROM DISK			
LIST/SELECT			
DELETE			
SAVE TO DISK			
(RE) DEFINE			
MACROCLIMATE			
ORIENTATION			
ROOF			
WALL			
FLOOR			
WINDOW/DOOR			
OVERHANG			
BLDG. SYSTEMS			
ANALYZE			
GRAPHICAL			
NUMERICAL			
IMPROVEMENTS			
P VS. A			
N. PENETRATION			
S. PENETRATION			
COMPARE			
			

Figure 53: Summary Energy Analysis Screen

3.6 IMPROVEMENTS Command Category

In the hope of improving energy performance, EDECT, when requested, will make a numeric determination on the energy design of three aspects of the current object; perimeter versus area, north fenestration and south fenestration. If directed further, the meaning of the determination and how it affects energy consumption will also be given. The determinations and explanations for all three aspects are handled similarly by EDECT.

3.6.1 P_VS_A

This command, when picked, displays the current objects perimeter versus area ratio in the Graphics Area of the 3251 display and a strip message no. 24 (YOU MAY REQUEST ADDITIONAL (EXPLANATION) OR (RETURN)) which asks the user if an explanation of the ratio is wanted (Figure 54). The word EXPLANATION of strip message no. 24 is light pen active and picking it will give the explanation to the determination below the determination in the Graphics Area. After the explanation is displayed the strip message box is cleared of all text except RETURN (Figure 55). Picking RETURN, whether or not an explanation is requested, clears the Graphics Area and Strip Message Box and reactivates the primary menu.

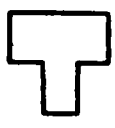

		NAME: 2 MACROCLIMATE: B-PRESNO OCCUPANTS: 8 BUILDING TYPE: RESIDENTIAL MECH. SYS.: GAS-FIRED LIGHTING SYS.: INCANDESCENT	
FOOTPRINT	SOUTHWEST VIEW		
YOU MAY REQUEST ADDITIONAL (EXPLANATION) OR			(RETURN)
<p>THE PERIMETER VS. AREA RATIO FOR THE CURRENT OBJECT IS:</p> <p style="text-align: center;">0.73</p>			<div data-bbox="1313 682 1503 714">OBJECT(S)</div> <div data-bbox="1313 714 1503 745">READ FROM DISK</div> <div data-bbox="1313 745 1503 777">LIST/SELECT</div> <div data-bbox="1313 777 1503 808">DELETE</div> <div data-bbox="1313 808 1503 840">SAVE TO DISK</div> <div data-bbox="1313 840 1503 871">(RE)DEFINE</div> <div data-bbox="1313 871 1503 903">MACROCLIMATE</div> <div data-bbox="1313 903 1503 934">ORIENTATION</div> <div data-bbox="1313 934 1503 966">ROOF</div> <div data-bbox="1313 966 1503 997">WALL</div> <div data-bbox="1313 997 1503 1029">FLOOR</div> <div data-bbox="1313 1029 1503 1060">WINDOW/DOOR</div> <div data-bbox="1313 1060 1503 1092">OVERHANG</div> <div data-bbox="1313 1092 1503 1123">BLSC. SYSTEMS</div> <div data-bbox="1313 1123 1503 1155">ANALYZE</div> <div data-bbox="1313 1155 1503 1186">GRAPHICAL</div> <div data-bbox="1313 1186 1503 1218">NUMERICAL</div> <div data-bbox="1313 1218 1503 1249">IMPROVEMENTS</div> <div data-bbox="1313 1249 1503 1281">P VS. A</div> <div data-bbox="1313 1281 1503 1312">M. PENETRATION</div> <div data-bbox="1313 1312 1503 1344">S. PENETRATION</div> <div data-bbox="1313 1344 1503 1375">COMPARE</div> <div data-bbox="1371 1375 1445 1438">STOP</div>

Figure 54: Screen After Picking P VS. A




 <p>1=40 FT</p>		NAME: 2 MACROCLIMATE: 8-FRESH OCCUPANTS: 9 BUILDING TYPE: RESIDENTIAL MECH. SYS.: GAS-FIRED LIGHTING SYS.: INCANDESCENT	
FOOTPRINT	SOUTHWEST VIEW		(RETURN)
<p>THE PERIMETER VS. AREA RATIO FOR THE CURRENT OBJECT IS:</p> <p style="text-align: center;">0.73</p> <p>AN IDEAL PERIMETER VS. AREA (P VS. A) RATIO IS 1.00. THE P VS. A RATIO CAN BE BROUGHT CLOSER TO 1.00 BY REDUCING THE LINEAR FEET OF EXPOSED WALL PER SQUARE FOOT OF FLOOR AREA.</p> <p>THE IDEAL P VS. A FLOOR PLAN SHAPE IS A CIRCLE.</p>			<div data-bbox="1306 674 1483 800"> OBJECT(S) READ FROM DISK LIST/SELECT DELETE SAVE TO DISK (RE)DEFINE </div> <div data-bbox="1306 800 1483 968"> MACROCLIMATE ORIENTATION ROOF WALL FLOOR WINDOW/DOOR OVERHANG BLDG. SYSTEMS </div> <div data-bbox="1306 1010 1483 1073"> ANALYZE GRAPHICAL NUMERICAL </div> <div data-bbox="1306 1094 1483 1178"> IMPROVEMENTS P VS. A N. FENESTRATION S. FENESTRATION </div> <div data-bbox="1306 1293 1483 1325">COMPARE</div> <div data-bbox="1364 1335 1438 1409">  </div>

Figure 55: Screen With P vs. A Ratio and Explanation

3.6.2 N. FENESTRATION

This command operates like the P VS. A command but, of course, with a different determination and explanation. The north fenestration determination is simply a percentage figure representing the amount of north oriented wall area taken up by openings. The next figure shows the determination and explanation for the example object (Figure 56).

38% OF THE CURRENT OBJECT NORTH ORIENTED WALLS ARE OPENINGS (DOORS/WINDOWS).

FROM AN ENERGY STANDPOINT, NORTH ORIENTED OPENINGS ARE DETRIMENTAL IN THAT THEY LOSE EXCESS AMOUNTS OF HEAT DURING A HEATING SEASON AND GAIN HEAT DURING A COOLING SEASON.

REDUCING THE SQUARE FOOTAGE OF NORTH ORIENTED OPENING WILL IMPROVE ENERGY PERFORMANCE.

Figure 56: Example N. Penetration Improvement Message

3.6.3 S. PENETRATION

This command also operates like P VS. A but its determination is a percentage representing the square footage of southern oriented openings which receive no beneficial shading throughout the year from overhangs. The following figure is the determination and explanation message for the example object (Figure 57).

27% OF THE CURRENT OBJECT SOUTH ORIENTED OPENINGS RECEIVE NO BENEFICIAL SHADING FROM ANY SHADING DEVICE.

NON-SHADED OPENING AREA GAIN EXCESSIVE INSOLATION HEAT. PROPERLY PLACED SHADING DEVICES (OVERHANGS) WILL IMPROVE ENERGY PERFORMANCE.

Figure 57: Example S. Penetration Improvement Message

3.7 COMPARE

This command initializes EDECT's process for comparing the graphical analyses of up to four objects coinstantaneously. When compare is picked the basic screen format is replaced with the screen shown in Figure 58. The Object List Area and Commands Area remain but the Graphics Area and Object Data Box are replaced with four equal sized comparison quadrants. Each quadrant is numbered in the upper left corner. The Object List Area contains a list of all objects in session memory while the primary menus are replaced with the Compare Secondary Menu (Figure 58).

1	2	1 2 3 4 5 6
3	4	MAIN MENU GRAPHICAL QUADRANT 1 2 3 4

Figure 58: Screen After Picking CCFABF

To bring an analysis graph and isometric image of an object into a quadrant the user follows a three step procedure: (1) pick the quadrant number (below the command QUADRANT), (2) pick the object (from the list of objects), (3) pick the command GRAPHICAL. The order of these steps is not critical, but all three need to be picked. Also, before the three steps are completed, the user may change the quadrant choice or the object number choice. Once the third step is chosen, the selected quadrant is filled immediately. The following figure shows the condition of the compare screen after quadrant number 1 and GRAPHICAL were picked. The

this case picking the object, has not been completed (Figure 59).

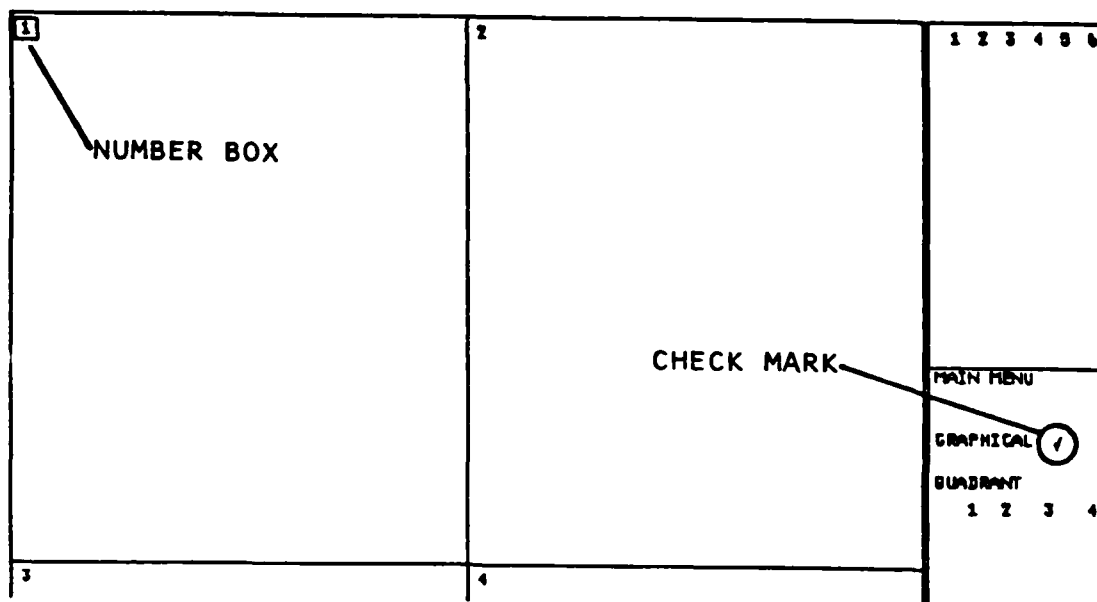


Figure 59: Upper Compare Screen Example

The Check Mark and Number Box appear after GRAPHICAL and the quadrant number are picked. They disappear when the quadrant is filled, that is, when the third step is accomplished. In the above example, the third step was picking object 2 from the Object List Area which resulted in plotting object 2's energy performance graph and the object isometric in quadrant 1 (Figure 60).

The energy graph is labeled with single digits or numbers which stand for (going counterclockwise):

- D - December
- S - September
- J - January
- M - March
- 6 - 6 A.M.
- N - Noon
- 6 - 6 P.M.
- M - Midnight .

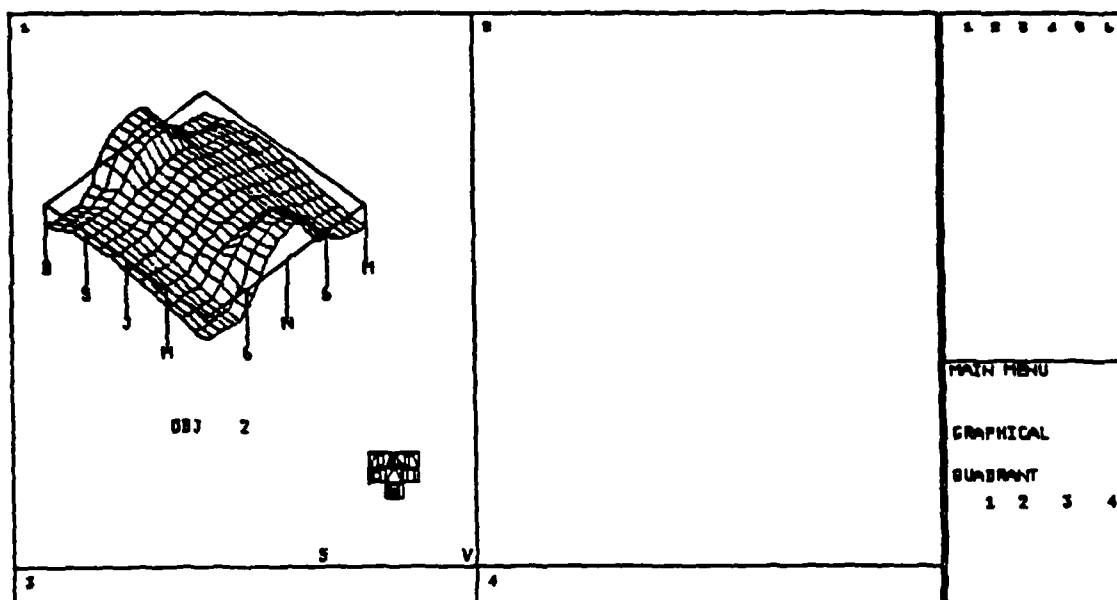


Figure 60: Upper Compare Screen w/ Quadrant 1 Filled

The letters S and V in the lower left hand corner of the quadrant are light pen activated and stand for scale and view respectively. They manipulate the isometric image of the object in the same way as the scale and view selects of the Object Data Box (see subsection 3.3.5) to give the user a more descriptive view of the object.

A quadrant can be filled more than once in a call to COMPARE with the obvious caution that any images already in that quadrant will be lost. Picking Main Menu returns the basic screen and primary menu. Whatever object was current before picking COMPARE will still be current and its description will appear in the Object Data Box.

The last image of this chapter is a compare screen with all four quadrants filled with different objects and their energy graphs (Figure 61).

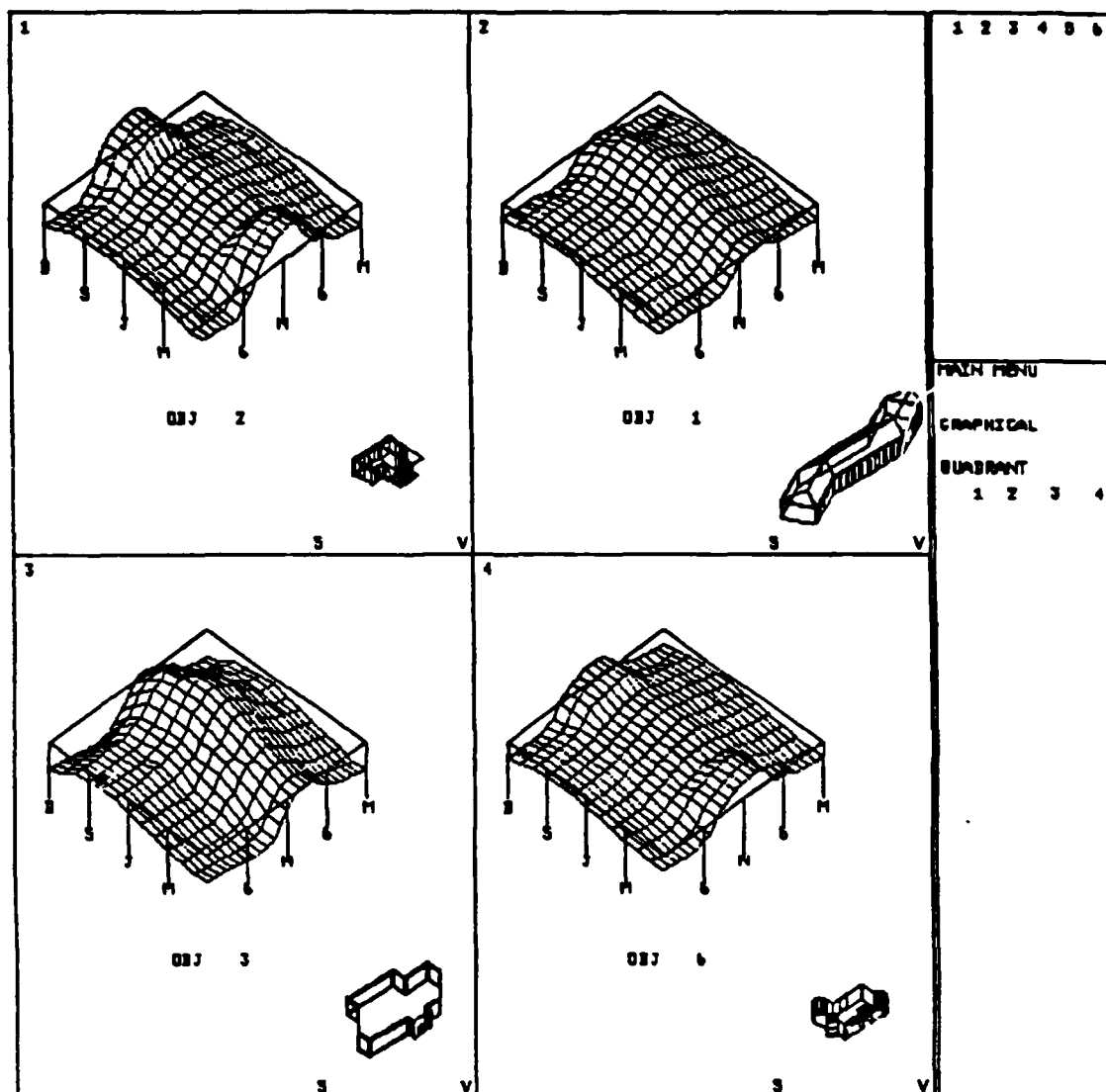


Figure 61: Compare Screen & Four Objects

4. An EDECT Design Example

This chapter presents an example of how the EDECT system can be used to improve a building design, with respect to energy efficiency. The building model used in this example was first created on the ARCHIMODOS system and saved on disk as object 1. This example and figures were taken from the first EDECT session in which object 1 was redefined.

4.1 Startup

As with all EDECT sessions, the first user action after the program has been brought up on the workstation (see Appendix C) is to read object data into session memory by picking READ FROM DISK from the Primary Command Area. For this example the number 1 appears in the object list area indicating that object 1 was the only model saved during the previous ARCHIMODOS session. Picking 1 from the Object List Area displays object 1's description in the Object Data Box as it initially exists (Figure 62).

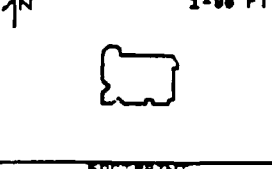

 FOOTPRINT	 SOUTH VIEW	NAME: 1 MACROCLIMATE: OCCUPANTS: BUILDING TYPE: MECH. SYS.: LIGHTING SYS.:
--------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------

Figure 62: Initial Object Data Box

The 3D data for object 1 contains interior wall faces as well as opening side, top, and bottom faces. Whenever EDECT displays the object's 3D image, as in the SOUTH VIEW of Figure 62, EDECT culls the data in a way such that after the cull only exterior faces and openings are displayed (Figure 63).

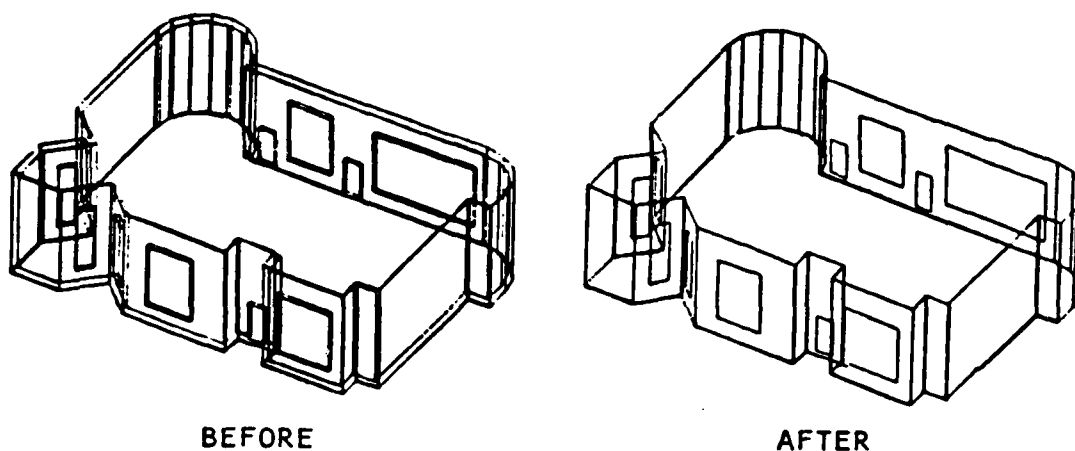


Figure 63: Example Object Before and After Culling

4.2 Initial Definitions

Object 1 comes into EDECT with all defaulted energy components and descriptions. In this example the first aspects to be user defined are the ones displayed in the object data box, i.e. macroclimate, occupants, building type, mech. system, and lighting system.

Macroclimate is defined by picking MACROCLIMATE from the primary commands followed by the number 4 on the United States icon (Figure 64). Picking RETURN in the strip message box registers the selection in session memory and the Object data box.

The other four aspects are user defined by picking primary command EIDG. SYSTEMS. The command brings up the four definition quadrants for building type, occupants, mechanical system, and lighting system. The selections picked for this example (Figure 65) were;

```

Building System  -> RESIDENTIAL
Occupants        -> 4
Mechanical System -> AIR HEAT PUMP
Lighting System  -> FLUORESCENT
  
```

These selections were registered with a pick of RETURN in the strip message box.

SELECT MICROCLIMATE NUMBER FROM MAP. TO REGISTER SELECTION		(RETURN)
MACROCLIMATES:		
1)HARTFORD, CT	9)CHARLESTON, SC	
2)MADISON, WI	10)LITTLE ROCK, AK	
3)BILLINGS, MT	11)KNOXVILLE, TN	
4)INDIANAPOLIS, IN	12)PHOENIX, AZ	
5)SALT LAKE CITY, UT	13)MIDLAND, TX	
6)ELY, NV	14)NEW ORLEANS, LA	
7)MEDFORD, OR	15)HOUSTON, TX	
8)FRESNO, CA	16)MIAMI, FL	

Figure 64: Macroclimate Definition Screen

PICK SELECTIONS. TO REGISTER SELECTIONS:		(SETUP)																																				
BUILDING TYPE: CLINIC COMMUNITY CENTER GYMNASIUM HOTEL-MOTEL APARTMENT > RESIDENTIAL OFFICE RETAIL WAREHOUSE	OCCUPANTS: <table border="1"> <thead> <tr> <th colspan="6">(PICK)</th> </tr> </thead> <tbody> <tr> <td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td> </tr> <tr> <td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td> </tr> <tr> <td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td> </tr> <tr> <td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td> </tr> <tr> <td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td> </tr> </tbody> </table> TOTAL: 4 (RESET)	(PICK)						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
(PICK)																																						
1	2	3	4	5	6																																	
7	8	9	10	11	12																																	
13	14	15	16	17	18																																	
19	20	21	22	23	24																																	
25	26	27	28	29	30																																	
MECHANICAL SYSTEM: OIL-FIRED GAS-FIRED STEAM CONVERTER RESISTANCE BOIL RESISTANCE STRIP WATER HEAT PUMP > AIR HEAT PUMP	LIGHTING SYSTEM: INCANDESCENT > FLOUPESCENT MERCURY VAPOR METAL HALIDE HIGH PRES SODIUM																																					

Figure 65: Building Systems Definition Screen

When the above initial definitions have been registered, all description items in the Object Data Box are filled. Also, the graphic images of the object (footprint and view) have been changed from the initial images by picking the scale and view selects in the Object Data Box (Figure 66).

		NAME: 1 MACROCLIMATE: 4-INDIANAPOLIS OCCUPANTS: 4 BUILDING TYPE: RESIDENTIAL MECH. SYS.: AIR HEAT PUMP LIGHTING SYS.: FLOUPESCENT
FOOTPRINT	SOUTHEAST VIEW	

Figure 66: Example Object Data Box After (Re)definition

Though the above definitions could have been left to system defaults, user definitions (even if only approximations) of projected building usage tend to yield more accurate energy analyses.

4.2.1 Graphical Analysis 1

At this point a graphical analysis is called for to give the user an idea of the object's energy performance and what the next step in the energy design might be (Figure 67).

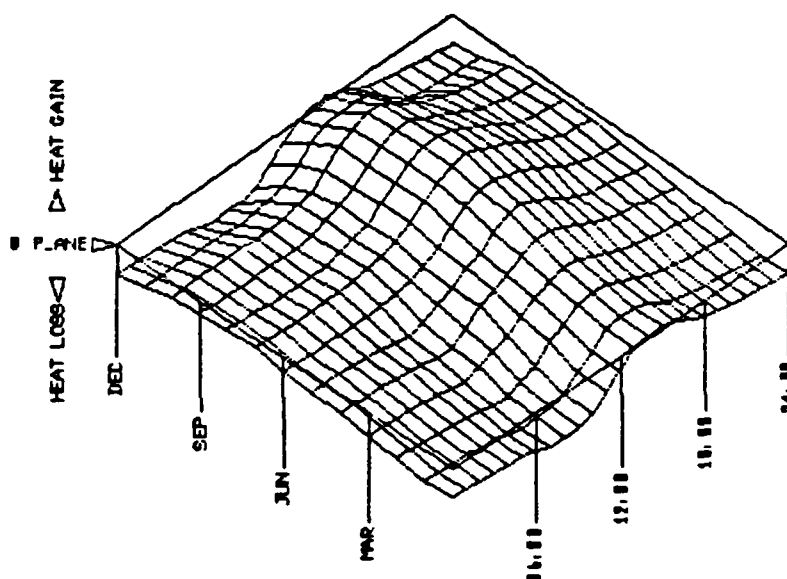




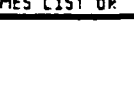

Figure 67: Initial Graphical Analysis of Example Object

The graph shows a 'heat mountain' - or summer heat gain and winter heat loss in the daytime - and fairly drastic night time heat loss all year. In other words, the initial object's envelope energy performance is poor. As presented in subsection 2.7.8, this graph is indicative of improper shading of south openings and less than adequate insulation and material selections. The balance of this chapter will demonstrate how better energy design can improve the example object's energy performance.

4.3 Initial Energy Design Improvements

Before proceeding with the EDECT session a copy of the example object is made on which future redefinitions will be done. This is accomplished by picking the primary command ORIENTATION and rotating object 1 in orientation quadrant 2

by 5 degrees then -5 degrees (picking 5 and -5 under secondary command DEGREES) followed by picking RETURN in strip message no. 5 (PICK DEGREES OR (RETURN)). The resultant footprint image in quadrant 2 has the same orientation as the initial object 1 but now a new name can be assigned to it by picking NEW SAVE. The NEW SAVE pick brings up the list of possible new names in the Object List Area (Figure 68) -

<div style="text-align: center;">  1"=40' FT </div> <div style="text-align: center; margin-top: 20px;">  </div>	<div style="text-align: center;">  </div>	NAME: 1 MACROCLIMATE: 4-INDIANAPOLIS OCCUPANTS: 4 BUILDING TYPE: RESIDENTIAL MECH. SYS.: AIR HEAT PUMP LIGHTING SYS.: FLOURESCENT
FOOTPRINT SOUTHEAST VIEW		
PICK NAME FROM AVAILABLE NAMES LIST OR (RETURN)		
<div style="text-align: center; border: 1px solid black; height: 150px; margin: 10px;"> 1 </div>	<div style="text-align: center; border: 1px solid black; height: 150px; margin: 10px;">  </div>	<div style="border: 1px solid black; height: 150px; margin: 10px;"></div>
<div style="text-align: center; border: 1px solid black; height: 150px; margin: 10px;"> 3 </div>	<div style="text-align: center; border: 1px solid black; height: 150px; margin: 10px;"> 4 </div>	<div style="border: 1px solid black; height: 150px; margin: 10px;"></div>

MAIN MENU

ACTIVE QUADRANT

1 2 3 4

(RE)ORIENT

DEGREES

-5

5

-15

15

-30

30

-45

45

-90

90

-180

180

CLEAR QUADRANT

1 2 3 4

SAME SAVE

NEW SAVE

2	3	4	5	6
7	8	9	10	11
12	13	14	15	16
17	18	19	20	21
22	23	24	25	26
27	28	29	30	31
32	33	34	35	36
37	38	39	40	41
42	43	44	45	46
47	48	49	50	51
52	53	54	55	56
57	58	59	60	61
62	63	64	65	66
67	68	69	70	71
72	73	74	75	76
77	78	79	80	81
82	83	84	85	86
87	88	89	90	91
92	93	94	95	96
97	98	99		

Figure 68: Upper Screen Before New Name Assignment

The number 2 is picked from the list after which the quadrant number 2 is picked thereby completing the copy process.

After returning to the primary menu from the orientation quadrants the primary command LIST/SELECT is picked and the Object List Area shows both object 1 and object 2 as residing in session memory (Figure 69).

AD-A171 261

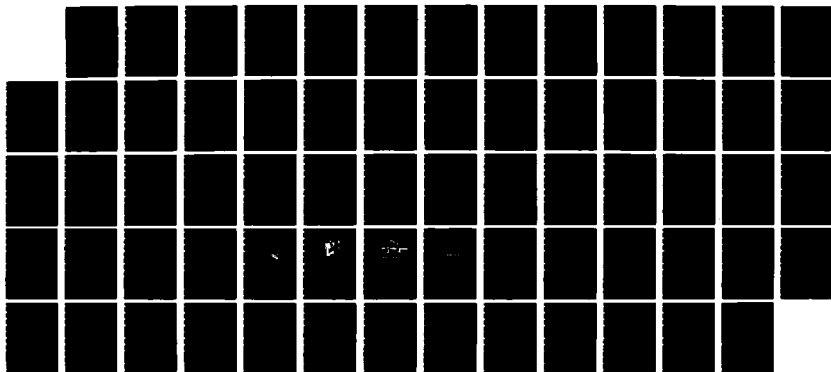
EDECT: AN ENERGY DESIGN EVALUATION AND COMPARISON TOOL
(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH
W D ALLEY 1986 AFIT/CI/NR-86-112T

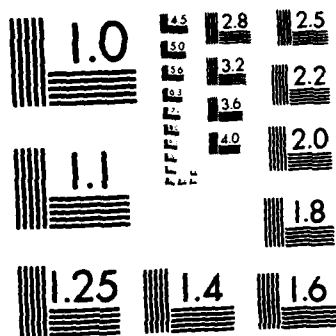
2/2

UNCLASSIFIED

F/G 9/2

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

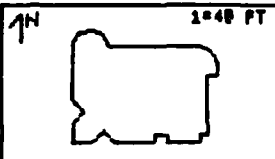
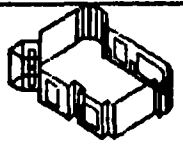
		NAME: 1 MACROCLIMATE: 4-INDIANAPOLIS OCCUPANTS: 4 BUILDING TYPE: RESIDENTIAL MECH. SYS.: AIR HEAT PUMP LIGHTING SYS.: FLOURESCENT	1 2
		FOOTPRINT	

Figure 69: Current Object Data and Object List

From the object list, object 2 is picked making it the current object. The Object Data Box shows that all of object 1's definitions were transcribed to object 2 at time of copy (Figure 70).

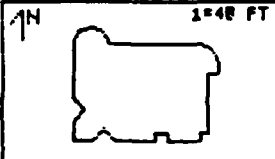
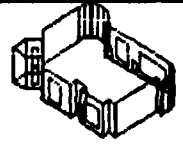
		NAME: 2 MACROCLIMATE: 4-INDIANAPOLIS OCCUPANTS: 4 BUILDING TYPE: RESIDENTIAL MECH. SYS.: AIR HEAT PUMP LIGHTING SYS.: FLOURESCENT
		FOOTPRINT

Figure 70: New Object's Description

4.3.1 Areas of Improvement

To aid in deciding which object aspects could be improved with EDECT, primary commands under IMPROVEMENTS are used. The command W. PENETRATION is picked first followed by EXPLANATION from strip message no. 24 (YCU MAY REQUEST ADDITIONAL (EXPLANATION) OR RETURN). The resultant screen indicates how much of the current object's north oriented walls are openings and what the result on energy consumption would be (Figure 71).

21% OF THE CURRENT OBJECT NORTH ORIENTED WALLS ARE OPENINGS (DOORS/WINDOWS).

FROM AN ENERGY STANDPOINT, NORTH ORIENTED OPENINGS ARE DETRIMENTAL IN THAT THEY LOSE EXCESS AMOUNTS OF HEAT DURING A HEATING SEASON AND GAIN HEAT DURING A COOLING SEASON.

REDUCING THE SQUARE FOOTAGE OF NORTH ORIENTED OPENING WILL IMPROVE ENERGY PERFORMANCE.

Figure 71: North Penetration Analysis and Explanation

The opening percentage, 21 %, is a figure that can and will be improved (see subsection 4.4.2).

The primary command S. FENESTRATION is picked next along with its explanation yielding south oriented opening shading information (Figure 72).

100% OF THE CURRENT OBJECT SOUTH ORIENTED OPENINGS RECEIVE NO BENEFICIAL SHADING FROM ANY SHADING DEVICE.

NON-SHADED OPENING AREA GAIN EXCESSIVE INSOLATION HEAT. PROPERLY PLACED SHADING DEVICES (OVERHANGS) WILL IMPROVE ENERGY PERFORMANCE.

Figure 72: South Penetration Analysis and Explanation

The 100 percent non-shaded opening figure is indicative of why the initial graphical analysis gave the poor 'heat mountain' curve and is the aspect of the current object that will be (re)designed first.

4.3.2 Overhang Definitions

The first attempt to improve the current object's energy design is by adding and manipulating overhangs on the southern oriented walls which have openings. In this example, five overhangs were initially added and manipulated (sized and positioned) over south openings (Figure 73). The first and second overhangs created (1 and 2) provide shading for openings of an adjacent wall as well as for openings of the wall on which they were defined. The number 3 overhang, in addition to shading the door-like opening, becomes infill to the object rather than a projection away from a wall (as overhangs 4 and 5 are).

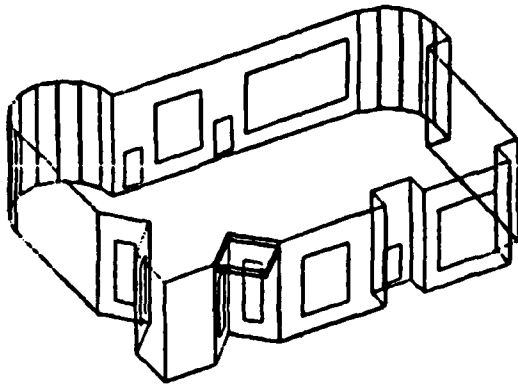
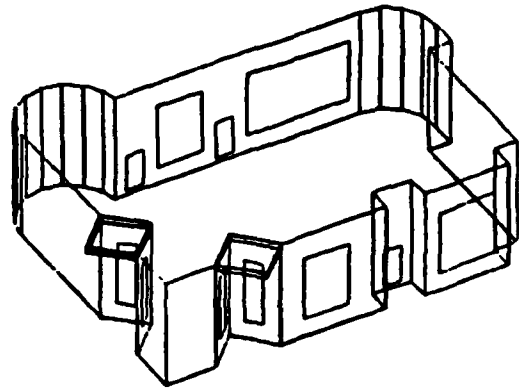
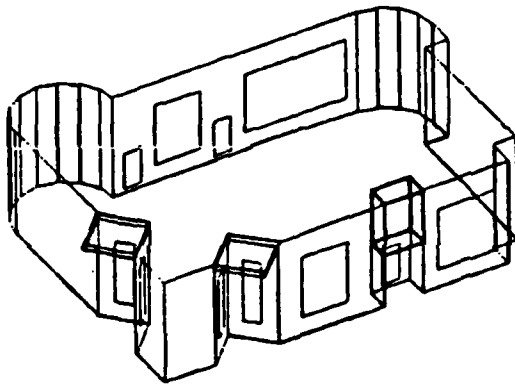
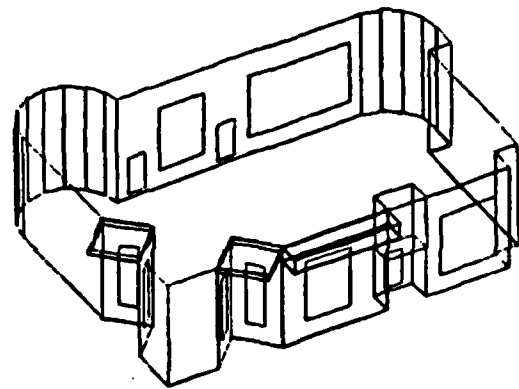
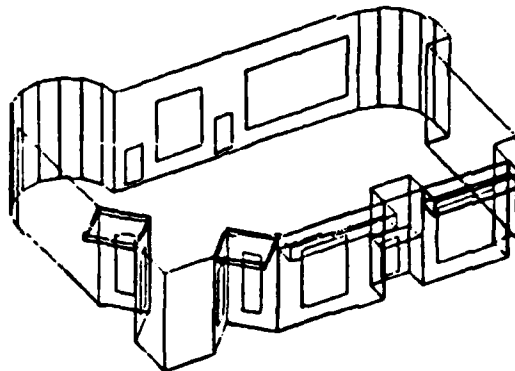
**1****2****3****4****5**

Figure 73: Initial Overhang Definitions

All five overhangs were registered as part of the current object by picking SELECT from the Overhang Secondary Menu after the overhangs had all been sized and positioned.

4.3.3 Graphical Analysis 2

With the initial overhangs defined, the impact of the overhangs on the object's energy performance is determined by first finding out how much of the south oriented openings have now been shaded (picking S. FENESTRATION) (Figure 74), and calling for an energy graph by picking primary command GRAPHICAL (Figure 75).

74% OF THE CURRENT OBJECT SOUTH ORIENTED OPENINGS RECEIVE NO BENEFICIAL SHADING FROM ANY SHADING DEVICE.

Figure 74: Percent Shading After Initial Overhang Additions

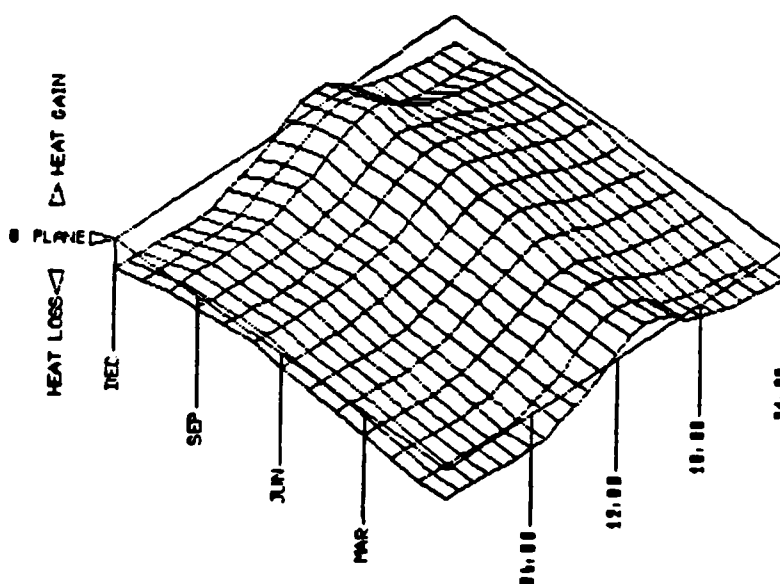


Figure 75: Energy Graph After Initial Overhang Additions

The shading percentage and graphical analysis show that the initial overhang additions improved performance somewhat. The graph shows a slight recession in the 'heat mountain' shape and the beginning of a 'saddle' shaped graph, which indicates some beneficial shading is occurring. However, much more can be done towards a better energy design.

4.4 Further Design Improvements - Openings and Overhangs

The next design change involves the south fenestration. Primary command WINDOW/DOOR is picked which brings up the basic window/door screen with light pen activated footprint (Figure 76).

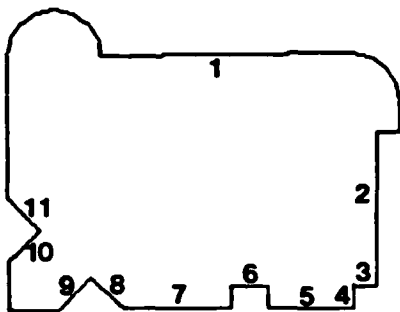
1																																					
2	<table border="1"> <thead> <tr> <th colspan="2">WINDOW/DOOR TYPES</th></tr> </thead> <tbody> <tr> <td colspan="2">CONSTRUCTION</td></tr> <tr> <td colspan="2">DOUBLE-HUNG WOOD FRAME WINDOW</td></tr> <tr> <td>1</td><td>NON-WEATHERSTRIPPED</td></tr> <tr> <td>2</td><td>WEATHERSTRIPPED</td></tr> <tr> <td colspan="2">DOUBLE-HUNG METAL FRAME WINDOW</td></tr> <tr> <td>3</td><td>NON-WEATHERSTRIPPED</td></tr> <tr> <td>4</td><td>WEATHERSTRIPPED</td></tr> <tr> <td colspan="2">ROLLED STEEL FRAME GLAZED WINDOW/DOOR</td></tr> <tr> <td>5</td><td>INDUSTRIAL PIVOTED (OR AWNING)</td></tr> <tr> <td>6</td><td>RESIDENTIAL CASMENT (OR HINGED)</td></tr> <tr> <td colspan="2">WOOD OR METAL DOOR</td></tr> <tr> <td>7</td><td>NON-WEATHERSTRIPPED</td></tr> <tr> <td>8</td><td>WEATHERSTRIPPED</td></tr> <tr> <td colspan="2">GLAZING</td></tr> <tr> <td>5</td><td>SINGLE</td></tr> <tr> <td>6</td><td>DOUBLE</td></tr> <tr> <td>7</td><td>TRIPLE</td></tr> </tbody> </table>	WINDOW/DOOR TYPES		CONSTRUCTION		DOUBLE-HUNG WOOD FRAME WINDOW		1	NON-WEATHERSTRIPPED	2	WEATHERSTRIPPED	DOUBLE-HUNG METAL FRAME WINDOW		3	NON-WEATHERSTRIPPED	4	WEATHERSTRIPPED	ROLLED STEEL FRAME GLAZED WINDOW/DOOR		5	INDUSTRIAL PIVOTED (OR AWNING)	6	RESIDENTIAL CASMENT (OR HINGED)	WOOD OR METAL DOOR		7	NON-WEATHERSTRIPPED	8	WEATHERSTRIPPED	GLAZING		5	SINGLE	6	DOUBLE	7	TRIPLE
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Figure 76: Basic Opening (Re)definition Screen for Example

The footprint of the above figure has certain wall segments numbered for later reference in this example.

Wall 7 (from the above figure) is the first wall picked for opening redefinition. The single original large opening is deleted and eight smaller openings are added and positioned so five of them are in a row under wall 7's overhang and the remaining three are stacked in a column along the right edge of the wall (Figure 77). This design change puts more opening square footage under the overhang and provides a visual

accent/framing to the door immediately to the right of wall 5 (in wall 6).

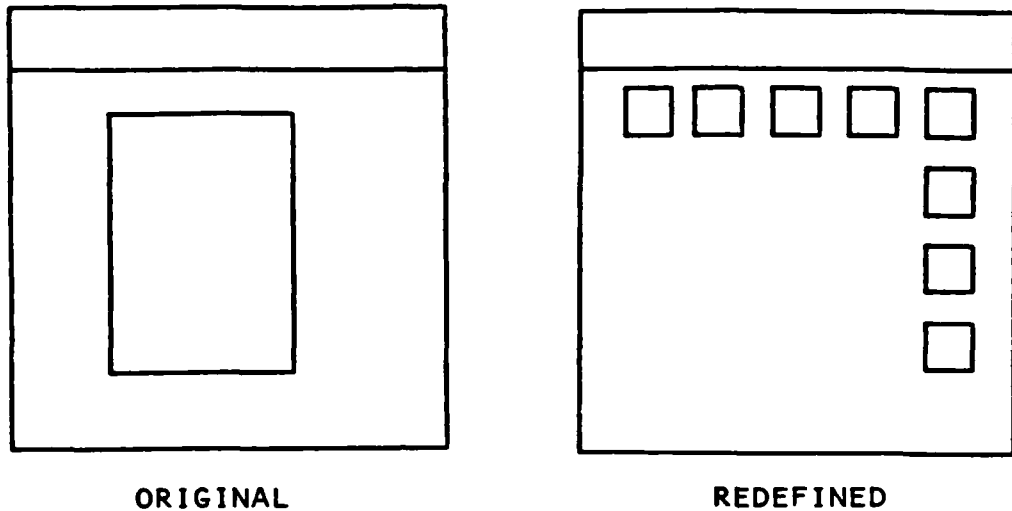


Figure 77: Opening Redefinition of Example Wall 7

The opening arrangement of the above figure is then brought back to the basic window/door screen by picking 1 from strip message no. 10 (SELECT OPENING->OPERATION, (RETURN), OR SAVE IN WINDOW (1) (2)). From the basic opening screen (Figure 78) the arrangement becomes part of the current object after the 1 under the secondary command SELECT is picked.

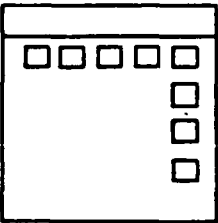
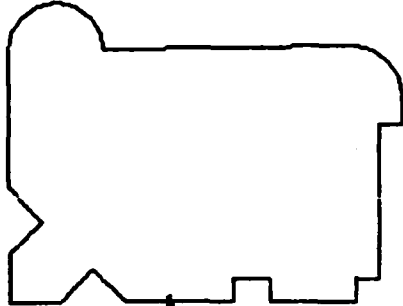
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GLAZING																			
9 SINGLE																			
8 DOUBLE																			
7 TRIPLE																			

Figure 78: Basic Opening Screen with Redefinition

Wall 5 is picked next for opening redefinition. Similar to wall 7's redesign, the original large opening is replaced by a grouping of seven smaller windows arranged along the top and down the left side of the wall (Figure 79). Again, the desired effect is to highlight the entrance to the left of wall 5 and put more opening space under the shading effect of the overhang.

This opening arrangement is made part of the current object as explained for wall 7.

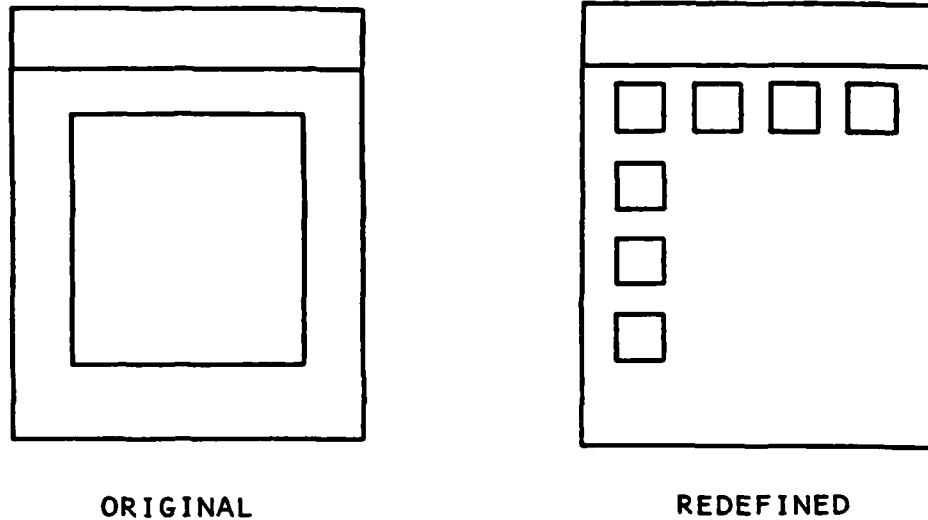


Figure 79: Opening Redefinition of Example Wall 7

Finally, walls 8, 9, 10, and 11 of the current object have their openings redefined so as to have the same opening arrangement. This is done by first picking the wall (either 8, 9, 10, or 11) then scaling and repositioning the the original opening and adding, scaling and repositioning another opening so the two openings are the same size with one positioned directly above the other (Figure 80).

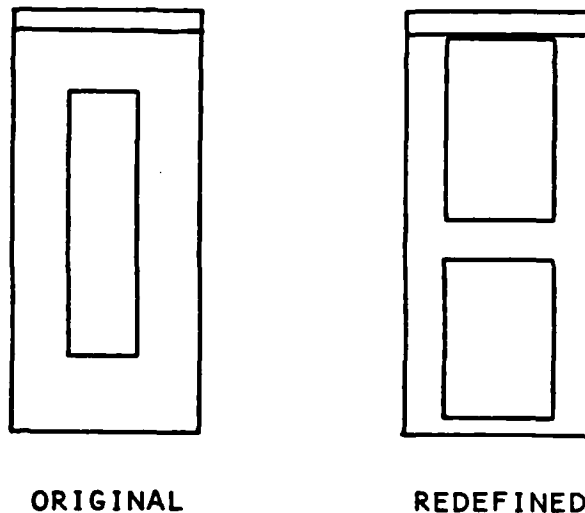


Figure 80: Opening Redefinition Example for Walls 8-11

The result of all the above opening manipulations is shown in the following figure (Figure 81).

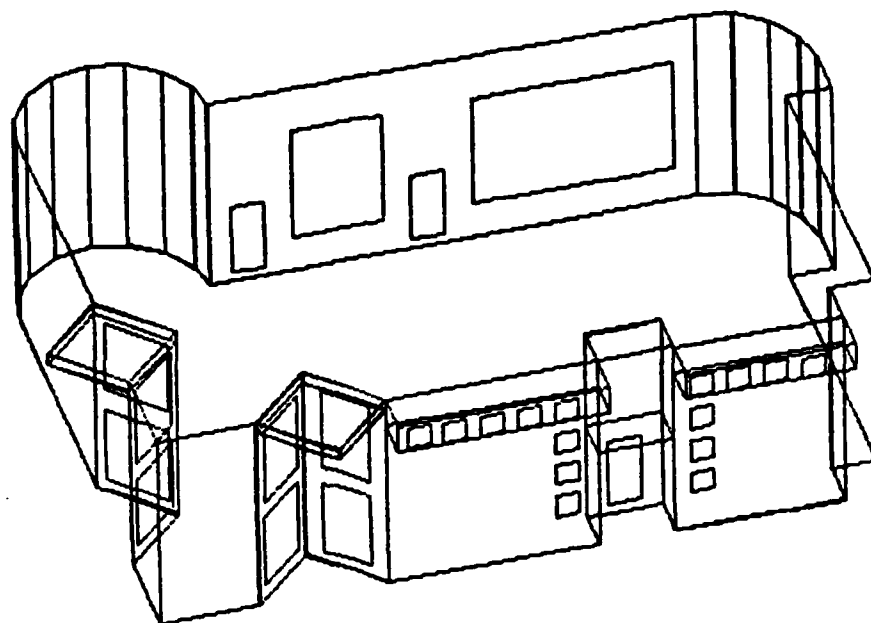


Figure 81: Resultant Example Object with Opening Changes

With the openings thus arranged, two more overhangs are added for the openings of walls 8, 9, 10, and 11 so that all the openings of these walls receive beneficial shading (Figure 82).

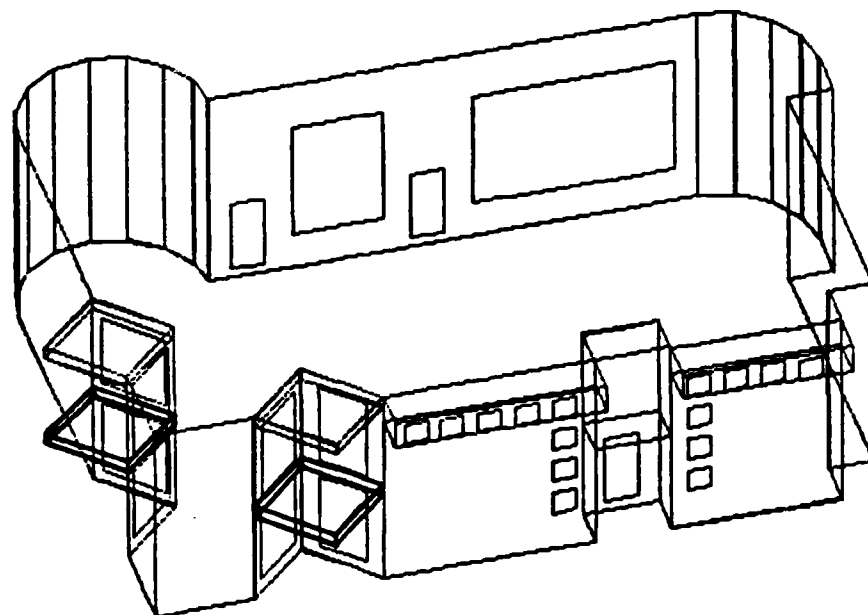


Figure 82: Example Object with Added Overhangs

4.4.1 Graphical Analysis 3

With the openings and overhangs defined as shown in the above figure an interim analysis is done to determine the effect of the changes. The percentage of south oriented shaded openings (Figure 83) has greatly increased and a graphical analysis (Figure 84) shows a definite 'saddle' shaped graph. Therefore, the fenestration and overhang (re)definitions had the desired outcome of shading south oriented openings so heat is gained only when needed.

14% OF THE CURRENT OBJECT SOUTH ORIENTED OPENINGS RECEIVE NO BENEFICIAL SHADING FROM ANY SHADING DEVICE.

Figure 83: Percent Shading After Further Redesign

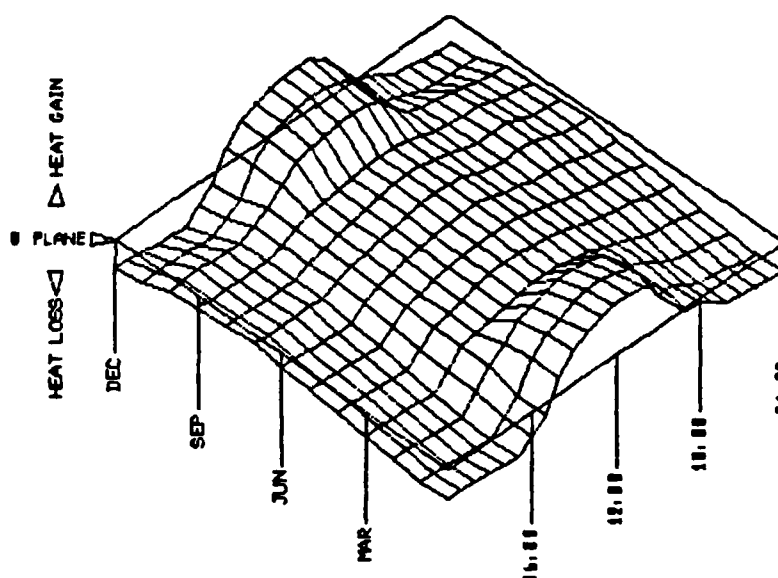


Figure 84: Graphical Analysis After Further Redesign

4.4.2 More Fenestration and Overhang (Re)definitions

In an effort to reduce the amount of north oriented openings, wall 1 is brought up through the window/door (re)definition routines and its four openings are changed. The two largest openings are first deleted and the remaining two openings, perceived as doors, are repositioned side by side near the middle of the wall. Next, seven new openings are added, sized, and positioned on either side of the doors in an abstract composition (Figure 85).

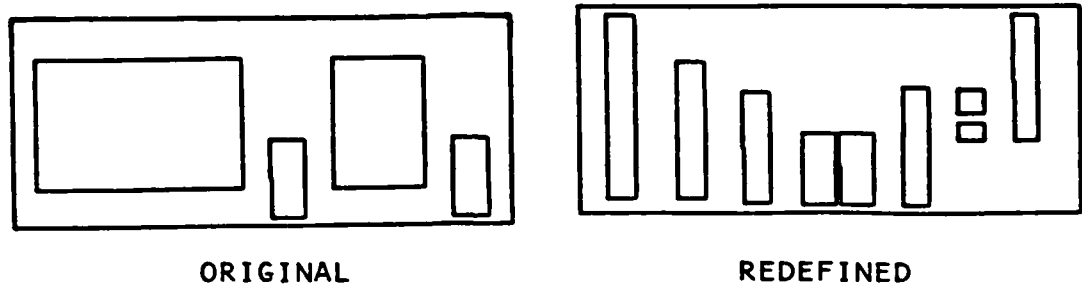


Figure 85: Opening Redefinition of Example Wall 1

The resulting north opening square footage reduce the percentage of north oriented openings by 5 percent - frcs 21 to 16 - (Figure 86).

16% OF THE CURRENT OBJECT NORTH ORIENTED WALLS ARE OPENINGS (DOORS/WINDOWS).

Figure 86: North Fenestration Analysis After Redefinition

A final design change to the current object's envelope is to continue the series of square windows - started with wall 5 - on walls 4, 3 and 2 and around to wall 1. Also, overhangs are added to walls 3 and 2 as a continuance to wall 5's overhang and to shade the strip of windows just added to those walls (Figure 87).

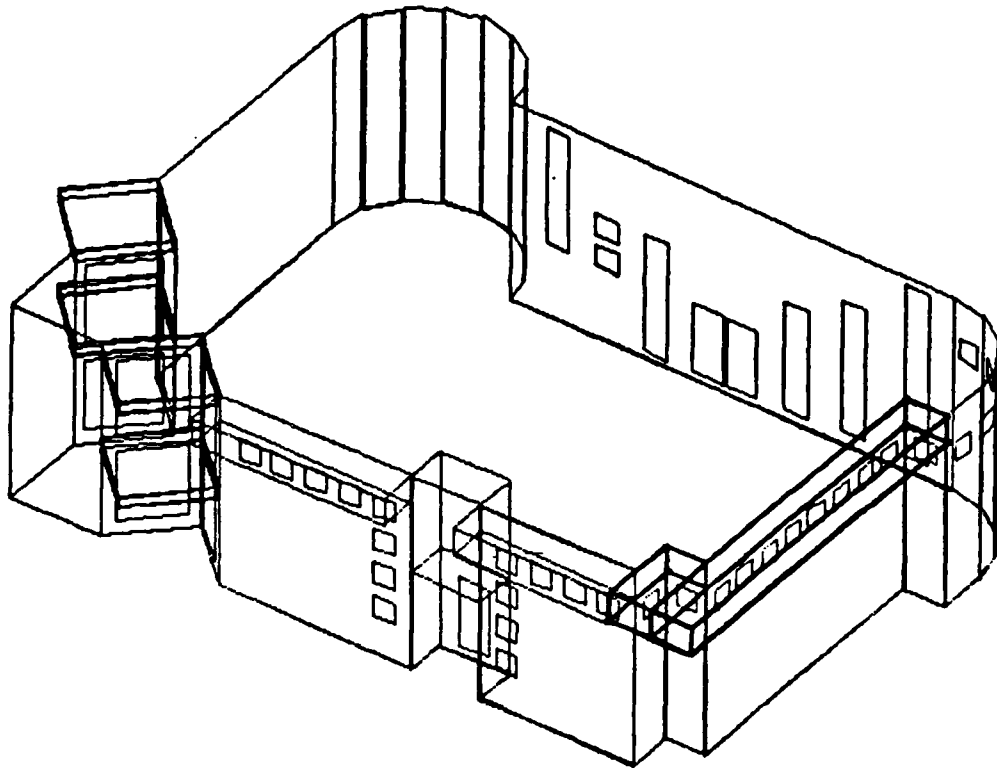


Figure 87: Object 2 with All (Re) definitions

4.5 Graphical Comparison

At this point it is useful to see how much the energy performance of the original object has been improved by the above changes and (re)definitions. This is done through EDECT's comparison ability.

The primary command COMPARE is picked which brings up the Compare Secondary Menu and a list of the objects (in session memory) in the Object List Area. In this example the object names that appear are 1 and 2. Next, object 1 is picked for display in comparison quadrant 1 and object 2 is picked for quadrant 2. With the energy graphs side by side the change in the envelope performance by redesigning the sample object's openings and adding overhangs in key locations is apparent. The original 'heat mountain' has been replaced by the more acceptable 'saddle' shaped graph (Figure 88).

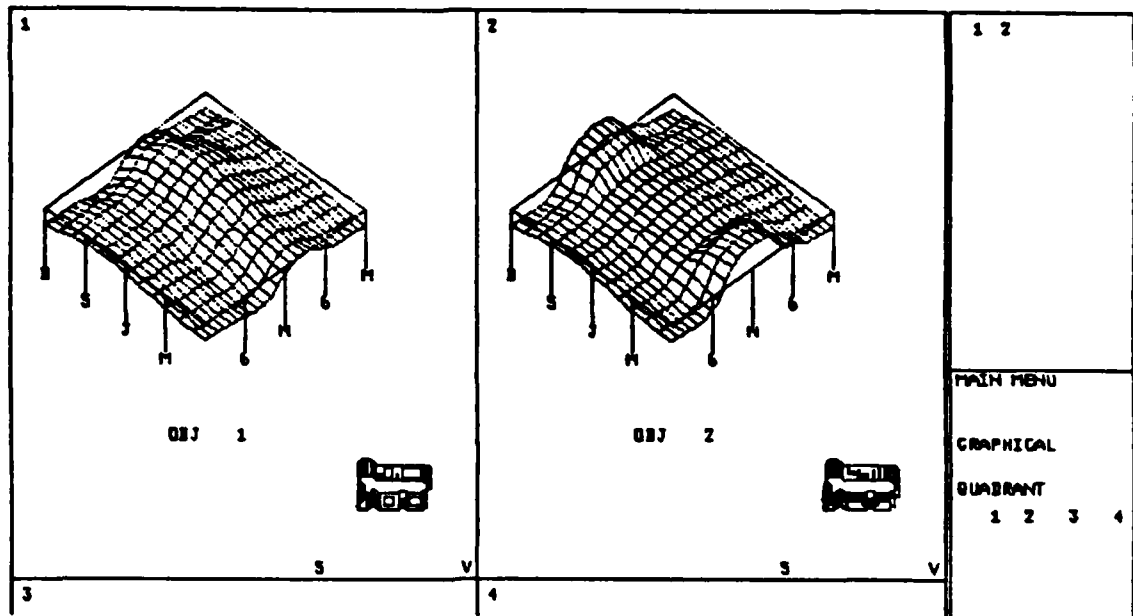


Figure 88: Comparison of Original and Redefined Objects

After sufficient visual inspection and comparison has been done between the two graphs, the primary commands and current object description (in the graphic data box) are brought back by picking the secondary command MAIN MENU in the Compare Secondary Menu.

The remainder of the example will be refinements to the redefined object (object 2) through building material type selections.

4.6 Final Definitions and Comparisons

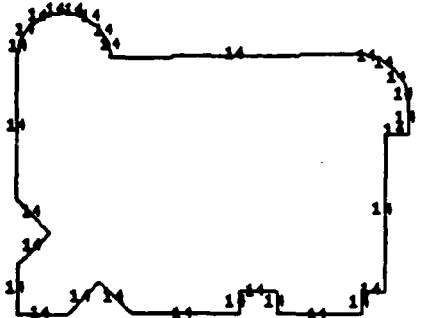
The first component of the current object to have its material type defined by the user, rather than defaulted, is the roof. The primary command ROOF (under the (RE)DEFINE header) is picked to bring up the roof selection menu.

According to the designer's preference, any one of the twelve available roof construction types can be selected. For this example, roof construction type 10 was picked then RETURN in strip message no. 20 (PICK ROOF CONSTRUCTION TYPE NUMBER, CR (RETURN)) was picked registering the selection as the current object's roof construction type (Figure 89).

PICK ROOF CONSTRUCTION TYPE NUMBER, OR	(RETURN)
ROOF TYPE: FLAT W/ SUSPENDED CEILING	
CURRENT CONSTRUCTION: 18	
AVAILABLE ROOF CONSTRUCTION TYPES:	
1. 1 RIGID INSULATION 1 WOOD.	8. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION 2 CONCRETE.
2. 2 RIGID INSULATION 2 WOOD.	9. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION 4 CONCRETE.
3. 1 RIGID INSULATION 1 CONCRETE.	10. BUILT-UP ROOF, 4 RIGID INSULATION 4 CONCRETE. 1/2 GYP BOARD.
4. 2 RIGID INSULATION 2 CONCRETE.	11. BUILT-UP ROOF, 4 CELLULAR GLASS INSULATION 4 CONCRETE. 1/2 GYP BOARD.
5. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION 2 CONCRETE. AIR SPACE. 1/2 GYP BOARD.	12. BUILT-UP ROOF, 8 CORN BOARD. 4 CONCRETE. 1/2 GYP BOARD.
6. BUILT-UP ROOF, 2 CELLULAR GLASS INSULATION 4 CONCRETE. AIR SPACE. 1/2 GYP BOARD.	
7. BUILT-UP ROOF, 4 CONCRETE. 2 CELLULAR GLASS INSULATION 2 CONCRETE.	

Figure 89: Roof Selection Menu with Example Definition

The next materials defined are for the wall construction types. For the current object it is assumed all exterior walls are of the same construction type. The quickest way to define a global wall construction type is (once the wall selection menu is brought into the Graphics Area by picking WALL) to assign the desired wall type to one wall then pick SELECT ALL from the Wall Secondary Menu. In the example, wall construction type 14 is picked and assigned to example wall 1 by picking wall 1's segment from the enlarged footprint. Then all walls of the footprint are defined as type 14 when SELECT ALL is picked (Figure 90). The wall construction type definition is assigned to the current object when MAIN MENU is picked. The main/primary commands and blank Graphics Area also return.

AVAILABLE WALL CONSTRUCTION TYPES:		
1. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 AIR SPACE. 1/2 GYP BOARD.		
2. 3/4 WOOD SIDING. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 GYP BOARD.		
3. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 3 1/2 GLASS WOOL. 1/2 PANELING.		
4. 3/4 WOOD SIDING. 7/8 WOOD FURRING. 8 CONCRETE BLOCK. 2 X 4 WOOD STUDS. 7/8 WOOD FURRING. 1/2 PANELING.		
5. 1 STUCCO. 6 CONCRETE. 1 GYP BOARD		
6. 1/2 CEMENT PLASTER. 4 FILLED CONCRETE BLOCK. AIRSPACE. 4 FILLED CONCRETE BLOCK. 1/2 CEMENT PLASTER.		
7. 1/2 CEMENT PLASTER. 4 CONCRETE BLOCK. AIRSPACE. 4 CONCRETE BLOCK. 1/2 CEMENT PLASTER.	13. 8 BRICK/CONC. BLOCK. 2 RIGID INSULATION. 1/2 GYP BOARD.	
8. 1/2 CEMENT PLASTER. 4 HOLLOW TERRA COTTA BLOCKS. AIRSPACE. 1/2 CEMENT PLASTER.	14. 6 PRECAST CONCRETE SANDWICH PANEL. 2 POLYURETHANE CORE.	
9. 6 SOLID BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD.	15. 10 BRICK CAVITY WALL. 2 RIGID INSULATION IN CAVITY.	
10. 6 HOLLOW BRICK. 1 X 2 FURRING. 1/2 GYP BOARD.	16. 10 BRICK CAVITY WALL.	
11. 6 HOLLOW BRICK. 2 RIGID INSULATION. 1/2 GYP BOARD.	17. 10 BRICK/CONC. BLOCK CAVITY WALL. 2 RIGID INSULATION IN CAVITY.	
12. 8 BRICK/CONC. BLOCK. 1 X 2 FURRING. 1/2 GYP BOARD.	18. 10 BRICK/CONC. BLOCK CAVITY WALL.	
	19. 4 BRICK VENEER. 1/2 INSULATION BOARD SHEATHING. 2 X 4 WOOD STUDS. BATT (R-11) INSULATION. 1/2 GYP BOARD.	

MAIN MENU
 SELECT ALL

Figure 90: Wall Selection Menu with Example Definitions

Finally the window/door construction and glazing types are defined. Somewhat like the wall type definitions, the window openings are, in this example, of one construction and glazing type and the doors of a different construction type. The straight forward way to do this for the example object is to first define one window opening as the desired type then select that type for all openings. Doors are later defined individually.

Specifically, the window/door manipulation menu and screen are again brought up by picking WINDOW/DOOR from the primary commands then example wall 8 is picked from the enlarged footprint bringing up the elevation of wall 8 in the Graphics Area. Rather than manipulating wall 8's openings it is returned to quadrant 1 of the initial window/door screen via strip message no. 10 (SELECT OPENING->OPERATION, (RETURN), OR SAVE IN WINDOW (1) (2)). Window/door secondary command

DEFINE TYPE is then picked followed by one of the openings in quadrant 1. The actual type definitions for the picked opening are made when construction type 4 and glazing type C are picked. With the one opening defined all openings receive the same definition when UNDEFINED is picked from strip message no. 15 (PICK OPENING-> TYPE. ALL (DEFINED) / (UNDEFINED) OPENINGS SAME? TO EXIT: (RETURN)). The doors are next defined separately by bringing up the elevations containing the door openings and assigning the desired door construction type to them (Figure 91). The tentative opening type definitions in the two quadrants are assigned to the current object by picking 1 and/or 2 under secondary command SELECT.


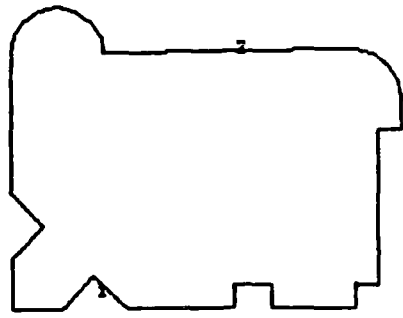
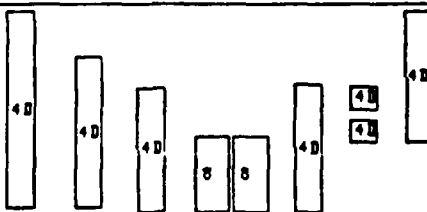
<p>1</p> 		<p>MAIN MENU</p> <p>OPENING ADD DELETE</p> <p>↕ SHAPE ↕</p> <p>↕ TRANS ↕</p> <p>DEFINE TYPE</p> <p>SELECT 1 2</p> <p>CLEAR 1 2</p>
<p>2</p> 	<p>WINDOW/DOOR TYPES</p> <p>CONSTRUCTION</p> <p>DOUBLE-HUNG WOOD FRAME WINDOW 1 NON-WEATHERSTRIPPED 2 WEATHERSTRIPPED</p> <p>DOUBLE-HUNG METAL FRAME WINDOW 3 NON-WEATHERSTRIPPED 4 WEATHERSTRIPPED</p> <p>ROLLED STEEL FRAME GLAZED WINDOW/DOOR 5 INDUSTRIAL PIVOTED (OR AWNING) 6 RESIDENTIAL CASEMENT (OR HINGED)</p> <p>WOOD OR METAL DOOR 7 NON-WEATHERSTRIPPED 8 WEATHERSTRIPPED</p> <p>GLAZING</p> <p>5 SINGLE 8 DOUBLE T TRIPLE</p>	

Figure 91: Example Screen with Opening Type Definitions

The effect of these type definitions is easily seen by doing another graphical analysis comparison between objects 1 and 2 (Figure 92). The 'saddle' shaped energy analysis graph for object 2 is still apparent but because of the improved

material U-value from the above type definitions the heat gain and loss extremes are dampened giving a flatter 'saddle' shape.

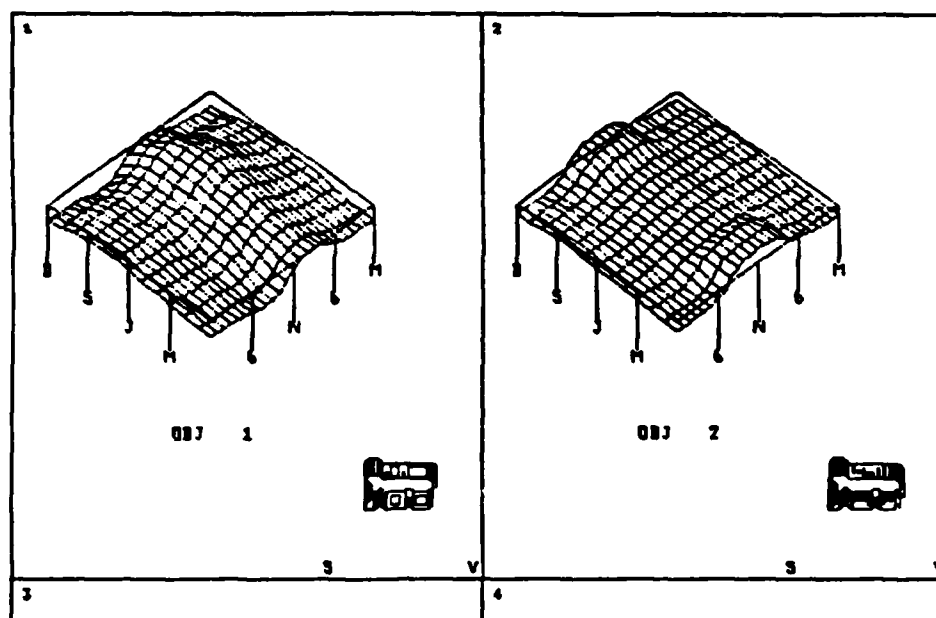


Figure 92: Graphical Comparison After Materials Definition

The last verification of the energy design improvements of object 2 over the original object 1 is done by invoking a numerical analysis on both (Figure 93).

=====		=====	
= ANNUAL ENERGY USE SUMMARY (MBTU) =		= ANNUAL ENERGY USE SUMMARY (MBTU) =	
=====		=====	
TOTAL HEATING ENERGY USE: 56		TOTAL HEATING ENERGY USE: 48	
TOTAL COOLING ENERGY USE: 461		TOTAL COOLING ENERGY USE: 312	
DOMESTIC HOT WATER FUEL USE: 88		DOMESTIC HOT WATER FUEL USE: 88	
TOTAL CONNECTED ELECTRICAL LOAD: 343		TOTAL CONNECTED ELECTRICAL LOAD: 343	
-----		-----	
TOTAL ANNUAL ENERGY USE: 810		TOTAL ANNUAL ENERGY USE: 753	
OBJECT 1		OBJECT 2	

Figure 93: Numerical Summaries of Example Objects 1 and 2

5. Internal Organizations

This chapter deals with the internal workings of EDECT in three sections. The first section details important data structures and object representations, the second covers the SEE analysis formulas and calculations used by EDECT, and the last section presents the more significant procedures and algorithms behind the system operations.

5.1 EDECT Data Structures

The data structures of EDECT fall into two general categories; shared and unique. Shared data structures are those common to both ARCHIMODOS and EDECT, while unique data structures are created and used by EDECT alone. Shared data structures are explained initially.

5.1.1 Shared ARCHIMODOS And EDECT Data Structures

The two systems 'share' four arrays which store the top level directory and the faces, edges, and vertices of the objects (Figure 94). This 'sharing' is only at a very basic level, e.g. ARCHIMODOS creates the data and EDECT reads and uses it. The reciprocal is not true.

3D Index Array: IND

At the top level of the data structure is the IND index array which is a directory of the 3D models. Each row of the array corresponds directly to the user supplied 3D name, allowing the definition of 99 separate objects. The first two columns of the array contain the begin and end pointers to the faces of the object in the IPF array, while the third and fourth columns identify the begin and end extents of the 3D vertices in the CR array (Figure 94).

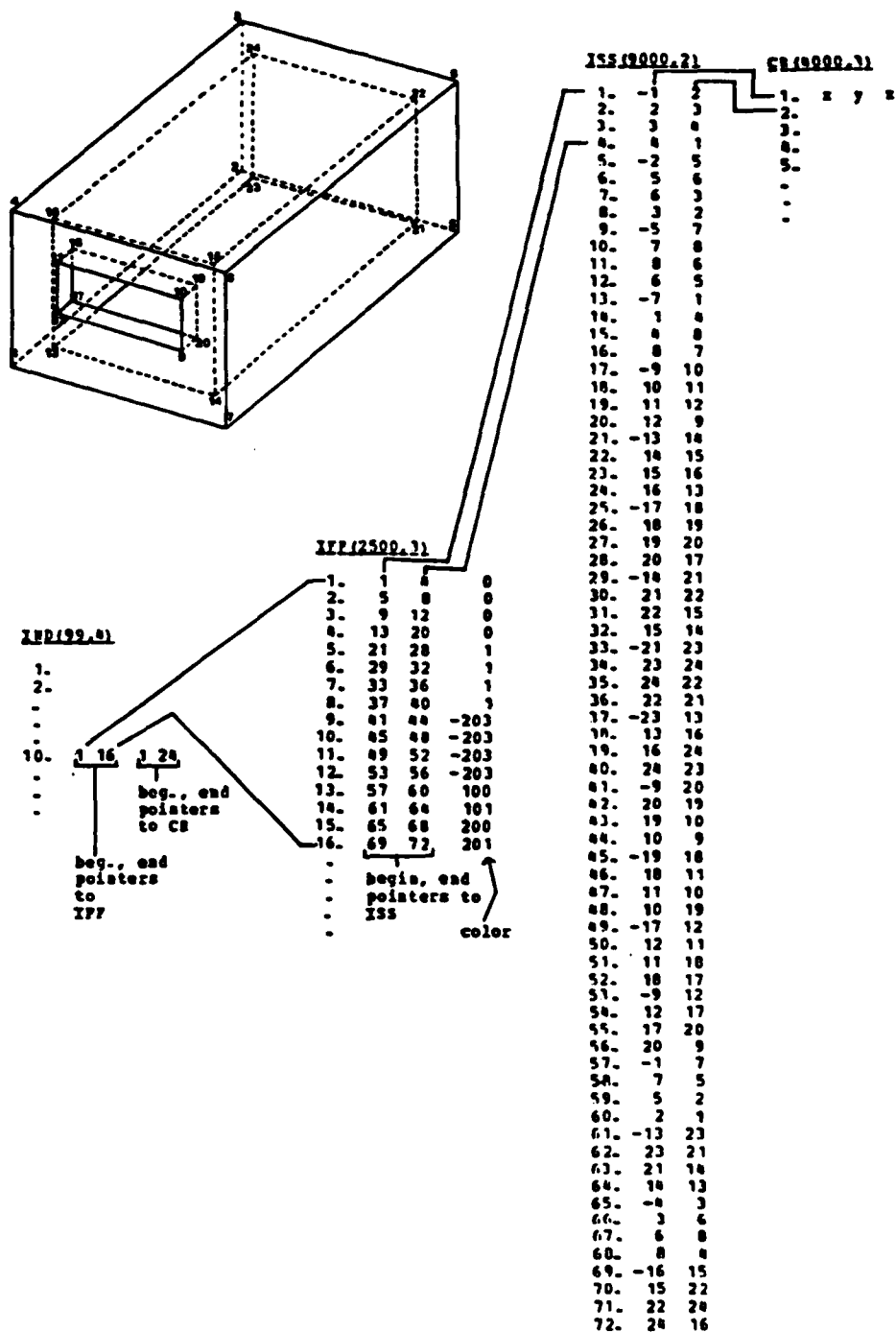


Figure 94: ARCHIMODOS/EDECT 3D Data - Taken From Actual Model

3D Face Array: IFP

At the next level is the IFP array which stores face definitions of the objects. A row in this array represents all polygons of a single face, including openings. The first two columns identify the begin and end extent of the face edges, which are stored sequentially in the ISS array. The third column of the IFP array contains a "color" attribute. This is used to identify particular attributes of a face. ARCHIMODCS assigns these colors in the following general way:

<u>color</u>	<u>code</u>
0	-> exterior wall
roofs counter	-> interior wall
-100 to -400	-> opening sides
199	-> open bottom
299	-> open top
100	-> bottom face
101 and up	-> interior floor faces
200	-> top face
201 and up	-> interior ceiling faces
401	-> roof bottom
402	-> roof top
403	-> roof sides .

3D Edge and Vertex Arrays: ISS & CP

At the lower levels of the data structure are the ISS and CP arrays. The CP coordinate array is a real value array which stores the X, Y, and Z component, in inches, for each of the vertices of the object. The ISS edge array maintains the connections between the vertices, where each row represents

a single edge, and the two columns locate its begin and end vertices, respectively, in the CR array. As noted for the IFF array, the edges are stored sequentially for each face. Since a single face can contain several polygons (openings), the first edge of each new polygon is marked with a negative value in column 1 of ISS. The outer polygon of complex faces is always stored first, to distinguish it from the openings (Figure 94).

5.1.2 Data Structures Unique to EDECT

From the shared 3D object data structure outlined above, EDECT extracts certain data (such as openings) and places it in its own data structures (procedure described in section 5.3). Those data structures, along with others describing the energy characteristics of an object, are used solely by EDECT and if saved to disk, are used from session to session.

Building Descriptor Array: IBLDG

The IBLDG array is a general purpose structure holding various pointers to other arrays and certain object definitions. The first two columns are beginning and ending pointers to the array holding the segments of an object's footprint. The next five columns hold object definitions when defined by the user (Figure 95).

IBLDG(99,7)

	1	2	3	4	5	6	7
1	Ft Seg Begin	Ft Seg End	Macro C	Occ	Bldg Type	Mech Sys	Light Sys
2							
3							
.							
.							
.							

99 ← object name

Where: Ft Seg Begin - pointer to beginning of footprint
segment array (FTSEG)

Ft Seg End - pointer to end of footprint
segment array (FTSEG)

Macro C - object macroclimate

Occ - number of occupants

Bldg Type - building type definition

Mech Sys - mechanical system for object

Light Sys - lighting system for object

Figure 95; IBLDG Descriptor Array

Footprint Segment Array: FTSEG

EDECT extracts the bottom segments of every exterior wall and places them in ordered sequence in the 2D array FTSEG. The first two columns of FTSEG hold the X and Y coordinates of the segment beginning point and the last two hold the end point X and Y coordinates (Figure 96). All coordinate pairs are in inches.

FTSEG(500,4)

	1	2	3	4
1	X Begin	Y Begin	X End	Y End
2				
3				
.				
.				
.				

500 <-- footprint segment

Where: X Begin - Beginning X coordinate of footprint segment

Y Begin - Beginning Y coordinate of footprint segment

X End - Ending X coordinate of footprint segment

Y End - Ending Y coordinate of footprint segment

Figure 96: 2D FTSEG Segment Array

Opening Arrays: IWNDR and WDCRD

Openings (windows/doors) are described in data with two parallel arrays: IWNDR and WDCRD. IWNDR is an integer array that holds both data extracted from the 3D model arrays and user defined information. Specifically, the first two columns of IWNDR are the object and wall segment the opening came from, and the last two contain user defined opening type and U-value (Figure 97).

WDCRD is a real array with the X, Y, and Z coordinate values of both the lower left and upper right corners of the opening. These entries may be extracted or user defined and are in inches (Figure 98).

IWNDR(9000,4)

	1	2	3	4
1	Obj	Wall Seg	Type	U-Val
2				
3				
.				
.				
.				

9000 <-- opening (window/door)

Where: Obj - object opening belongs to
 Wall Seg - wall segment opening belongs to
 Type - opening type
 U-Val - opening U-value

Figure 97: IWNDR Opening Array

WDCRD(9000,6)

	1	2	3	4	5	6
1	Xll	Yll	Zll	Xur	Yur	Zur
2						
3						
.						
.						
.						

9000 <-- opening (window/door)

Where: Xll - X coordinate of lower left opening corner
 Yll - Y coordinate of lower left opening corner
 Zll - Z coordinate of lower left opening corner
 Xur - X coordinate of upper right opening corner
 Yur - Y coordinate of upper right opening corner
 Zur - Z coordinate of upper right opening corner

Figure 98: WDCRD Opening Array

Overhang Arrays: IOVHG and OVCRD

All overhangs in EDECT are user defined and represented in two parallel arrays: IOVHG and OVCRD. IOVHG is an integer array with two columns for the object name and wall which the overhang belong to (Figure 99).

The real array OVCRD holds coordinate and geometric description information for each overhang. The lower left and upper right hand corner coordinates of the overhang's backface are stored in the first six columns and the last column retains the perpendicular distance the overhang's front face is away from the wall (Figure 100). The back and front faces of an EDECT overhang are the same size and shape and parallel to each other. With the data from OVCRD and knowing the angle of the wall, EDECT determines the coordinates of the lower left and upper right coordinates of the overhang front face through basic mensuration calculations. With all overhang coordinates established, EDECT 'connects' vertices to form the image of top, bottom, side, front and back faces (Figure 101).

IOVHG(1000,2)

	1	2
1	Obj	Wall
2		
3		
.		
.		
.		

1000 ← overhang

Where: Obj - object overhang belongs to

Wall - object belongs to

Figure 99: IOVHG Overhang Array

OVCRD(1000,7)

	1	2	3	4	5	6	7
1	Xll	Yll	Zll	Xur	Yur	Zur	Ovpd
2							
3							
.							
.							
.							

1000 <-- overhang

Where: Xll - X coordinate of lower left corner of overhang back face
 Yll - Y coordinate of lower left corner of overhang back face
 Zll - Z coordinate of lower left corner of overhang back face
 Xur - X coordinate of upper right corner of overhang back face
 Yur - Y coordinate of upper right corner of overhang back face
 Zur - Z coordinate of upper right corner of overhang back face
 Ovpd - Overhang perpendicular distance away from wall

Figure 100: OVCRD Overhang Array

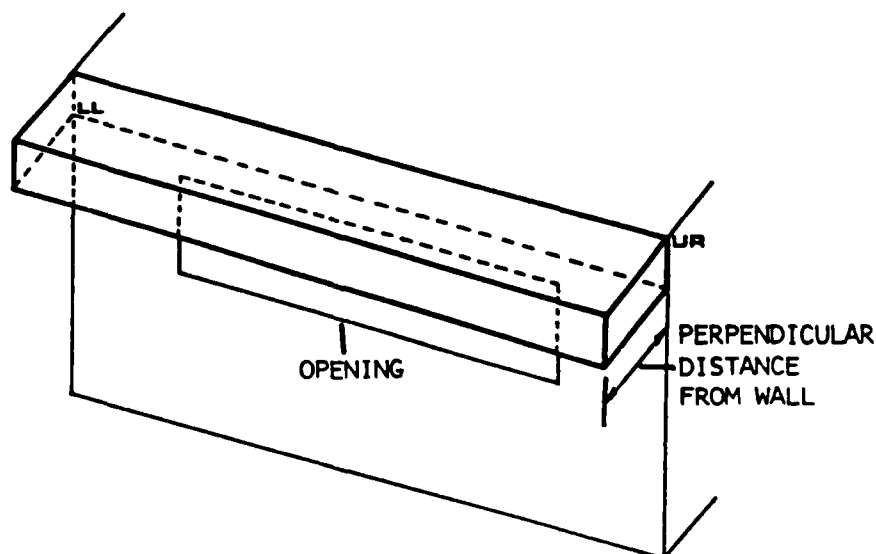


Figure 101: Overhang Description

Roof Descriptor Arrays: IRUFST and RCTP

User defined roof characteristics are held in the two parallel arrays IRUFST and RCTP. The integer array IRUFST has two columns; the first for the roof construction of an object and the second for the type of roof, i.e. 1, 2, or flat (Figure 102). The real array RCTP also has two columns, one for a roof's thickness and the other for the roof U-value (Figure 103).

IRUFST(99,2)

	1	2
1	Const	Type
2		
3		
.		
.		
.		

99 <-- object

Where: Const - roof type construction for object

Type - roof type of object

Figure 102: IRUFST Roof Array

RCTP(99,2)

	1	2
1	Thick	U-val
2		
3		
.		
.		
.		

99 <-- object

Where: Thick - roof thickness of object

Type - roof U-value of object

Figure 103: RCTP Roof Array

Wall Descriptor Arrays: IVALST and WCTP

All walls of an EDECT object have their wall properties in two arrays which, in addition to being parallel to each other are parallel to the IPF array described in subsection 5.1.1. Though not all faces of the IPF array are exterior, the ones that are and have user defined properties have corresponding entries in the arrays IVALST and WCTP.

IVALST, an integer array, keeps the wall type (Figure 104) and the real array WCTP saves wall thickness and U-value (Figure 105).

IVALST(25001

	1	1	1
1	Type		
2			
3			

·
·
·

2500 <-- wall

Where: Type - wall type

Figure 104: IVALST Wall Array

WCTP(2500,2)

	1	2	1
1	Thick	U-val	
2			
3			

·
·
·

2500 <-- wall

Where: Thick - wall thickness

U-val - wall U-value

Figure 105: WCTP Wall Array

5.2 EDECT Calculations

The many calculation formulae used by EDECT are mostly from the SEE method of determining heat loss/gain in buildings. SEE can be used to determine daily (as in the graph analysis), weekly, monthly, or annual energy performance. The following subsection details the SEE computations followed by a subsection on non-SEE calculations used during energy use determination and at other times. All equations in this section are numbered with the number enclosed in brackets - < >.

5.2.1 SEE/EDECT Energy Equations

For the results of SEE method calculations to be correct, several outside sources of information are used inside the formulae (2). These sources come from a variety of places such as ASHRAE data lists, U.S. Weather Bureau statistics, etc. SEE itself uses a variety of tabular data specially prepared to speed up its operations. The necessary source data for EDECT's running of SEE is prestored on disk and called into session memory during an EDECT run (see Appendix C for details). When used in the following equations, this prestored data will be referred to as coming from 'table'.

The SEE method is divided into three areas: building heat loss, building heat gain, and annual energy use summary. The presentation below follows those divisions.

Building Heat Loss Calculations

$$\begin{aligned} <5.1> \text{ Roof U-value} * \text{Roof Area} = \text{Roof Heat Loss} \\ & \hspace{15em} (\text{BTU/degree F} * \text{hr.}) \end{aligned}$$

$$\begin{aligned} <5.2> \text{ Wall U-value} * (\text{Wall Area} - \text{Opening Area}) = \\ & \hspace{15em} \text{Wall Heat Loss} \\ & \hspace{15em} (\text{BTU/degree F} * \text{hr.}) \end{aligned}$$

$$\begin{aligned} <5.3> \text{ Glass U-value} * \text{Glass Area} = \text{Glass Heat Loss} \\ & \hspace{15em} (\text{BTU/degree F} * \text{hr.}) \end{aligned}$$

$$<5.4> \text{ Door U-value} * \text{Door Area} = \text{Door Heat Loss}$$

(BTU/degree F * hr.)

**<5.5> Infiltration Factor * Infiltration Rate * Length of
Crack of All Openings = Infiltration Heat Loss
(BTU/ degree F * hr.)**

**Infiltration Factor -> 0.018 (specific heat of air
* air density)**

Infiltration Rate -> from table per const. type

Length of Crack -> sum of all opening perimeters

<5.6> Slab Edge Length * Heat Loss Rate = Floor Heat Loss
(BTU/degree F * hr.)

Slab Edge Length -> Footprint Perimeter

Heat Loss Rate -> taken as .55 w/ insulation

**<5.7> Total Heat Loss Through Envelope = (<5.1> + <5.2> +
(BTU/degree F * hr.) <5.3> + <5.4> +
<5.5> + <5.6>)**

**<5.8> Ventilation Factor * Ventilation Rate * Occupied Set
Point Temp. = Ventilation Heat Loss/Hr. Operated
(BTU/hr.)**

Ventilation Factor -> an accepted constant of 1.08

Ventilation Rate -> Occupants * 15 (by code)

Occupied Set Point Temp. -> (defaulted at 70 F)

<5.9> Total Building Heat Loss = <5.7> * Temp. Difference
(BTU/hr.)

Temp. Difference -> difference between outside and
inside air temperature. Outside
air temp. taken from table per
macroclimate, inside air temp.
assumed set at 70 degrees F.

<5.10> Occupied Heating Load = (<5.8> + <5.9>) * Occupied
(BTU) Hrs.

Occupied Hrs. -> from table per building type

<5.11> Unoccupied Heating Hours = <5.9> * unoccupied hrs.
(BTU)

<5.12> Total Building Heating Load = <5.10> + <5.11>
(BTU)

Building Heat Gain Calculations

<5.13> Roof U-value * Roof Area * Equivalent Temp.
Difference = Roof Heat Gain
(BTU/hr.)

Equivalent Temp. Difference -> from table per
roof type

<5.14> Wall U-value * (Wall Area - Opening Area) *
 Equivalent Temp. Difference = Wall Heat Gain
 (BTU/hr.)

Equivalent Temp. Difference -> from table per
 wall type

<5.15> Total Wall Heat Gain = Sum of All Wall Heat Gains
 (BTU/hr.)

<5.16> Glass Area * Avg. Solar Gain * Shading Coefficient *
 Latitude Factor = Glass Heat Gain
 (BTU/hr.)

Avg. Solar Gain -> from table

Shading Coefficient -> percent of glazing shaded by
 overhang w/ sun angle ≥ 45
 degrees

Latitude Factor -> from table per macroclimate

<5.17> Total Glass Heat Gain = Sum of All Window Heat Gains
 (BTU/hr.)

<5.18> Total Average Sol-air Gain = <5.13> + <5.14> +
 (BTU/hr.) <5.17>

<5.19> Avg. Winter Sol-air Gain = <5.18> * % Winter Sun
 (BTU/hr.)

% Winter Sun -> from table per macroclimate

**<5.20> Avg. Summer Sol-air Gain = <5.18> * % Summer Sun
(BTU/hr.)**

% Summer Sun -> from table per macroclimate

**<5.21> Sol-air Increment = <5.19> - <5.20>
(BTU/hr.)**

**<5.22> Occupants * Heat Gain per Occupant =
Occupant Heat Gain
(BTU/hr.)**

Heat Gain per Occupant -> from activity table

**<5.23> Total Connected Lighting Watts *
Utilization Factor * Heat to Space Conversion *
Conversion Factor = Lighting Heat Gain
(BTU/hr.)**

Total Connected Lighting Watts -> from table

Utilization Factor -> from use type table

Heat to Space Conversion -> 0.8 (constant)

Conversion Factor -> 3.4 (BTU/Watt * hr.)

**<5.24> Process Heat to Space + Equipment Heat to Space =
Total Misc. Heat Gain
(BTU/hr.)**

Process Heat to Space -> from table

**Equipment Heat to Space -> from table per mechanical
system**

**<5.25> Total Heat Gain = <5.21> + <5.22> + <5.23> + <5.24>
(BTU/hr.)**

<5.26> Enthalpy Difference * Ventilation Rate =
Ventilation Heat Gain
(BTU/hr.)

Enthalpy Difference -> Outdoor Air Enthalpy (table)
- Indoor Air Enthalpy (table)

Ventilation Rate -> Occupants * 15 (by code)

<5.27> Occupied Cooling Load = (<5.25> + <5.26>) * Occupied
(BTU) Hrs.

Occupied Hrs. -> from table per building type

<5.28> Unoccupied Cooling Load = <5.25> * Unoccupied Hrs.
(BTU)

Unoccupied Hrs. -> from table per building type

<5.29> Total Building Cooling Load = <5.27> + <5.28>
(BTU)

Annual Energy Use Summary Calculations

<5.30> Occupants * Hot Water Usage = Annual Water Usage
(Gallons)

Hot Water Usage -> from table per building type

**<5.31> Conversion Factor * <5.30> * Temp. Difference =
Domestic Hot Water (DHW) Load
(BTU)**

Conversion Factor -> 8.33 (pounds/gallon)

**Temp. Difference -> assumed 60 degrees F (between
hot and cold water)**

**<5.32> (<5.31> * DHW System Efficiency) / Fuel Heating
Value = DHW Use
(BTU)**

DHW System Efficiency -> from table per system

Fuel Heating Value -> from table per fuel type

**<5.33> Lighting Load * Building Square Footage * Annual
Occupancy Rate = Annual Lighting Load
(BTU)**

Lighting Load -> from table per system

**Annual Occupancy Rate -> from table per building
type**

**<5.34> Mech. System Load * Building Square Footage * Annual
Occupancy Rate = Annual Systems Load
(BTU)**

Mech. System Load -> from table per mech. system

**Annual Occupancy Rate -> from table per building
type**

**<5.35> Total Annual Energy Use = <5.12> + <5.29> +
<5.32> + <5.35>**

5.2.2 Other EDECT Equations

Certain formulae are used in energy determinations and in other EDECT procedures. They are not unique to the SFF method but bear mentioning here.

Footprint Area

The area enclosed by the segments of an object footprint represent the object's floor plan square footage in SFF and EDECT. With the segments already in order in the array FTSEG, determining the area is a matter of tracing the X and Y coordinates of each segment beginning and end point and multiplying them according to the equation:

$$\langle 5.36 \rangle \quad 1/2 * (X_1*Y_1 + X_2*Y_3 \dots + X_{n-1}*Y_n + X_n*Y_1 - Y_1*X_2 - Y_2*X_3 \dots - Y_{n-1}*X_n - Y_n*X_1).$$

The parenthesis in <5.36> can be remembered in a cross multiplying relationship with all X coordinates forming an ordered top row and all Y coordinates a bottom (Figure 106).

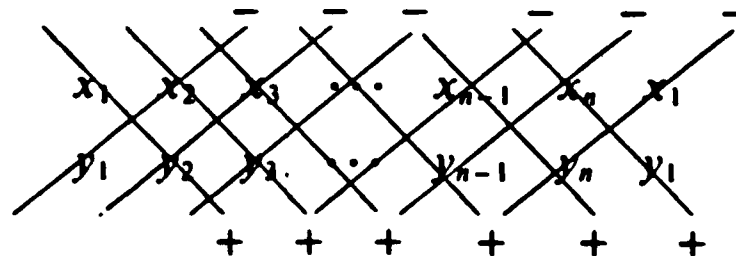


Figure 106: Polygonal Area Determination

This area determination technique is also used for walls and openings.

Type 2 Roof Areas

Type 2 shell roofs, or roofs with cathedral/open ceilings present more area to insolation than roofs with suspended ceilings. For sol-air calculations this extra area is determined by knowing the roof ridge height and distance from the eave to a perpendicular line from the ridge (Figure 107).

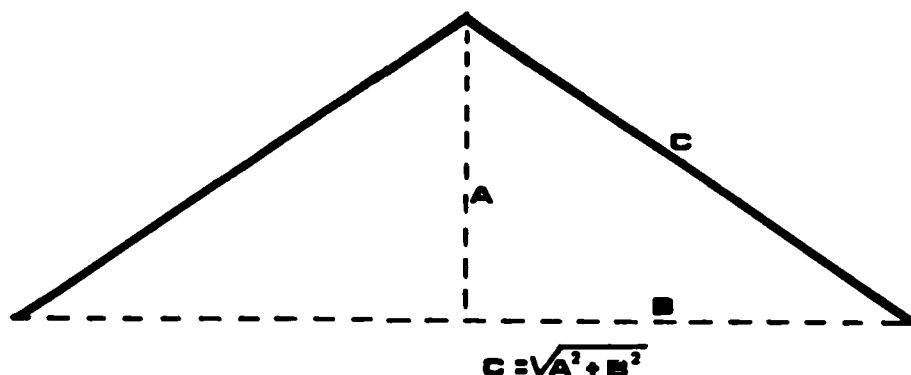


Figure 107: Roof Area Determination Basis

In Figure 107 - a schematic roof cross section - A represents the ridge height, B the distance between eave and perpendicular A, and C the true length of the roof spar. True area for the example roof face would be C times the eave length at the base of roof face. SEP simplifies multifaceted pitched roof area determination by applying a ratio to the floor plan area based on the ridge height.

Finding Perimeter vs. Area

P vs. A is the quotient of an object's perimeter divided by its area. The area of an object is taken as the footprint area (above) and the perimeter is the sum of all the true lengths of all footprint segments.

To arrive at the optimum P vs. A for any object is a two step process. First, the diameter and circumference of a circle with the same area as the footprint is found:

$$<5.37> \text{ Diameter} = ((\text{Footprint Area} * 4) / \text{Pi}) ** -2$$

$$\text{Pi} \rightarrow 3.14159$$

$$** -2 \rightarrow \text{square root}$$

$$<5.38> \text{ Circumference} = \text{Pi} * <5.37>$$

The second step is to find P vs. A for the circle:

<5.39> Best P vs. A = <5.38> / Footprint Area

The ratio EDECT displays when the user picks the IMPROVEMENT command P VS. A is:

<5.40> P vs. A Ratio = Best P vs. A / Actual P vs. A

5.3 Algorithms

EDECT is not an extensive algorithmic based system. What algorithms EDECT is based on deal primarily with extracting geometric information from the 3D object model.

5.3.1 Culling Non-Exterior Faces/Openings

To simplify an object's display image and load opening data into the array WDCRD, EDECT scans the array IFF to eliminate all non-exterior faces and identify openings. Two basic premises for this culling operation is that all faces generated for a structured 3D model on the ARCHIMODOS system have four vertices and likewise all openings have four vertices.

This procedure is for the displaying of the object image. The 3D data of arrays IND, IFF, ISS and CF is never changed or destroyed. It may simply be 'skipped over' as it is traced. (Figure 108). The steps are:

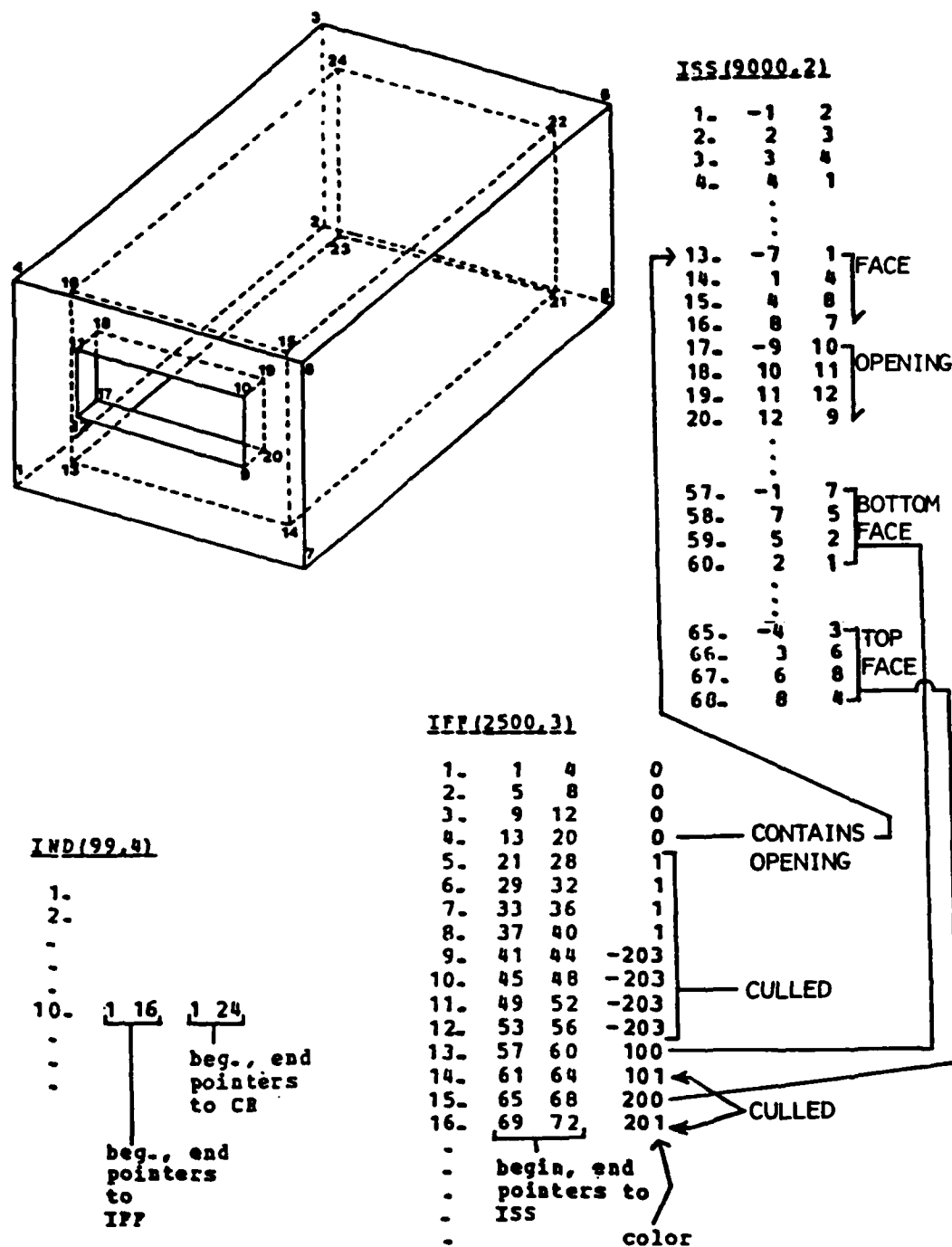


Figure 108: Exterior Face/Opening Display Illustration

- I. Read the beginning and end IPF pointers for an object from IND.
- II. Trace the third (color) column of IPF per pointers from Step I. If color is;
 - A. 0, 100 (4 vertices), 200, 402 or 403 --> display face.
 - B. 100 with greater than 4 vertices, find number of vertices in face by subtracting IPF column 2 from IPF column 1. If number of vertices is greater than 4 the face has openings. The number of openings is number of vertices divided by 4, minus 1.
 1. To load lower left and upper right corner coordinates into WDCED, count ahead in the ISS array for the corresponding opening segments from the openings found in Step C.
 2. The X, Y, and Z of the second opening vertex are the upper right corner coordinates. The X, Y, and Z of the fourth opening vertex is the lower left corner coordinates.
 3. Display face tracing only first four face vertices from IPF to ISS to CR.
 4. Display opening(s) using data from WDCRD.
 - C. Other than A above, skip to next face.

The resulting display image is made up of only exterior side, top, and bottom faces with the outline of openings appearing on the parent side face (Figure 109).

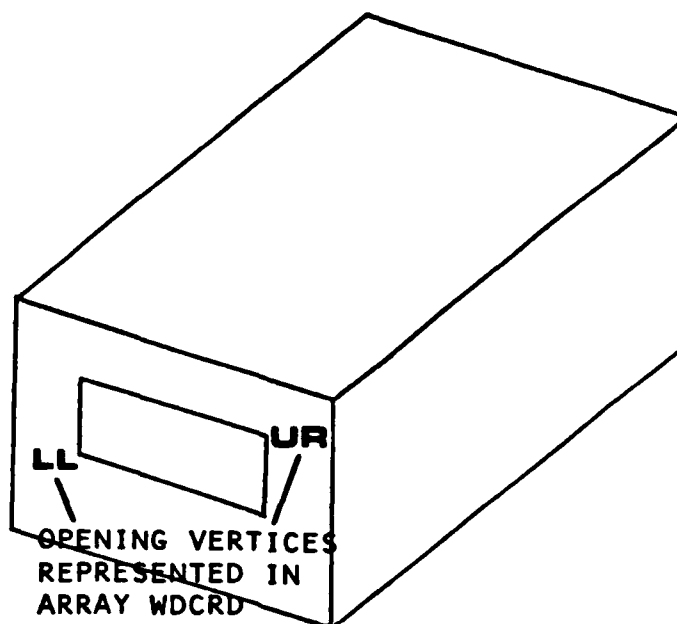


Figure 109: Post Culling Object Image

5.3.2 Loading the Array FTSEG

The segments of a footprint are extracted from the 3D data in a tracing operation similar to the culling described above. The difference is that when the color 100 is encountered in column 3 of IFF, EDECT traces the segments in ISS per the IFF pointers and stores only the X and Y coordinates of each vertex in FTSEG. The beginning and ending for a footprint's segments in FTSEG are recorded in the first two columns, respectively, of IBLDG.

5.3.3 Wall Angle and Orientation

The angle and orientation of a wall is needed for several EDECT operations including finding the true length of a footprint segment, finding true exterior wall and opening areas, and direction a wall is facing for insolation calculations.

The orientation is figured by first taking the starting and finishing vertex coordinates of the footprint segment pertaining to the wall and with the equation:

$$\langle 5.41 \rangle \text{ Angle} = \text{Arctan} ((Y_f - Y_s) / (X_f - X_s))$$

$X_s, Y_s \rightarrow$ starting vertex coordinates

$X_f, Y_f \rightarrow$ finishing vertex coordinates

Angle \rightarrow oriented with North being
0 degrees

get the angle of the segment. The orientation (Figure 110), or direction the wall is facing, is then:

$$\langle 5.42 \rangle \text{ Orientation} = \langle 5.41 \rangle - 90 \text{ degrees} .$$

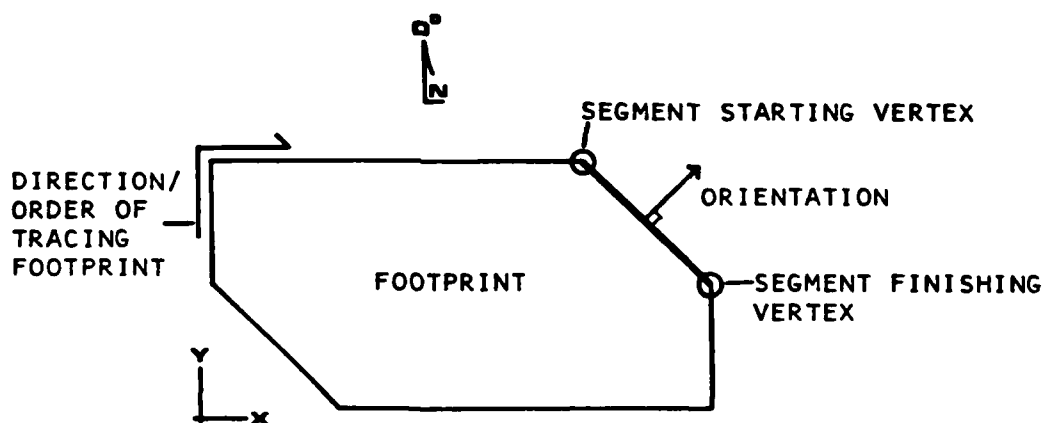


Figure 110: Geometries of An EDECT Footprint

To arrive at a segments true length, and ultimately coordinates to calculate true wall/opening area, EDECT rotates all coordinates associated with that segment (e.g. wall, opening, etc.) by an angle determined as follows:

$$\langle 5.43 \rangle \text{ Angle of Rotation} = -\langle 5.41 \rangle - 90 \text{ degrees} .$$

This has the effect of essentially rotating the segment/coordinates counterclockwise about the object origin

until it faces due south. Thus, a difference in X ($X_s - X_f$) is not foreshortened from the true distance.

6. Extensions and Conclusion

The goals set before beginning design of EDECT were, in large part, met by the system's subsequent implementation. It was to be a tool to help a designer rapidly visualize and learn from the consequences of early design decisions in envelope dominant building types. I feel it does that. But to say it is a complete energy design package, or that there is no need of extension to further enhance EDECT performance, would be vain and wrong. Following are some of the more significant extensions.

6.1 Enhanced ARCHIMODOS - EDECT Communication

The type of object EDECT can handle from ARCHIMODOS has certain restrictions, and communicating EDECT modifications back to ARCHIMODOS is impossible. In an academic environment where resources (especially time) are limited and reworking past projects is shied away from, any changes to ARCHIMODOS to accommodate EDECT data must be minimal.

To get away from relying on the assumption that all ARCHIMODOS walls have only four points and that openings must be 'extracted' from a wall in data, two basic changes could be made: (1) all openings and overhangs be represented individually in data and (2) a relationship identifier between faces of an object be established. To separate openings from walls would not necessarily mean an independent data structure as with EDECT's WDCRD array. Instead, the model arrays shared by the two systems could basically remain as they are with openings occupying their own IFF array row in lieu of being part of a wall description. Then each face could be tagged with an identifier similar to, but more extensive than, the IFF color column now in use. The identifier key could relate outside faces to inside walls, openings to walls, side faces to openings, overhang faces to walls and each other, etc., as well as keep the current color scheme. It would occupy more digit locations than the present color, but each digit location or group of digits would represent a specific relationship to (an) other face(s) of the object. Openings and overhangs could then be added or deleted more directly to data with EDECT doing the print-

er adjusting to insure complete object description - for both systems - and no stray data.

6.2 Hardcopies of EDECT Figures

The only way EDECT can now preserve images it creates after ending a session is by making screen dumps from the 3251 display of the desired image after it appears on screen. After terminating a session the user can retrieve these screen dumps and make print files from them for printing on an IBM 3287 dot matrix printer (Figure 111). Many of the figures in this thesis were done using this process.

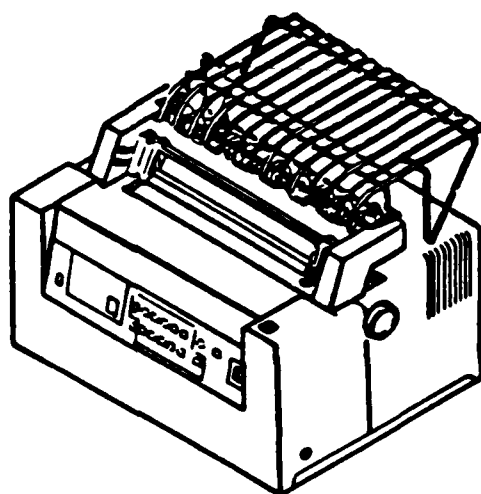


Figure 111: IBM 3287 Printer

Besides being slow, the above process yields image lines that are often 'jagged' due to the matrix nature of the printer. Only vertical and horizontal lines are printed without 'jaggies'. Any other angled line is actually a series of dot segments approximated to where the straight line would be. Certain energy graphs and other images would be much clearer if the aliasing (jaggedness) were not there. An extension to plot EDECT images on a vector type plotter, such as the Hewlett-Packard 7585B (Figure 112), would eliminate this problem.

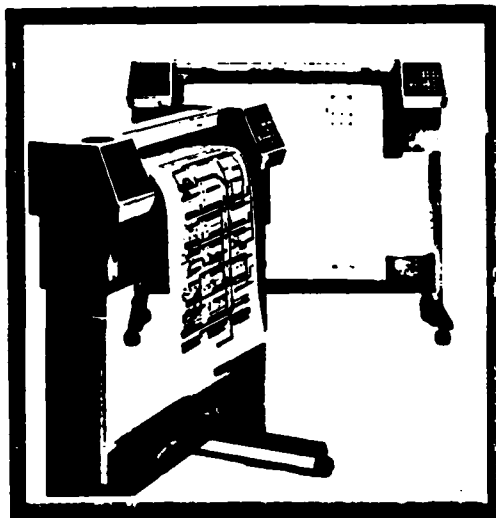


Figure 112: Hewlett-Packard Plotters

6.3 The Surrounding Environment

Rarely in today's built environment do buildings stand alone on a flat plane. An edifice may be enclosed by vegetation and/or a varying topography, and in an urban setting, enclosed by other structures. Whatever the surrounding, it influences energy performance to some degree or another (Figure 113).

The energy consumption of a 'stand alone' building may be drastically different if the same design is placed among mature trees or tall buildings. Shading patterns and wind currents can be totally different when the natural and man-made environment are figured in.

Given two designs, if design A has a better energy performance than design B in a 'stand alone' simulation, it will also have better performance in any environment as long as both are analyzed in the same environment. Thus EDECT's comparison/qualitative ability is valid for arriving at a 'best' energy design. However the quantitative determinations of heat gain/loss are valid only in the pseudo 'stand alone' setting. To compensate, EDECT would have to be extended to recognize and account for nearby buildings/changing vegetation growth and their appreciable effect on the subject object.

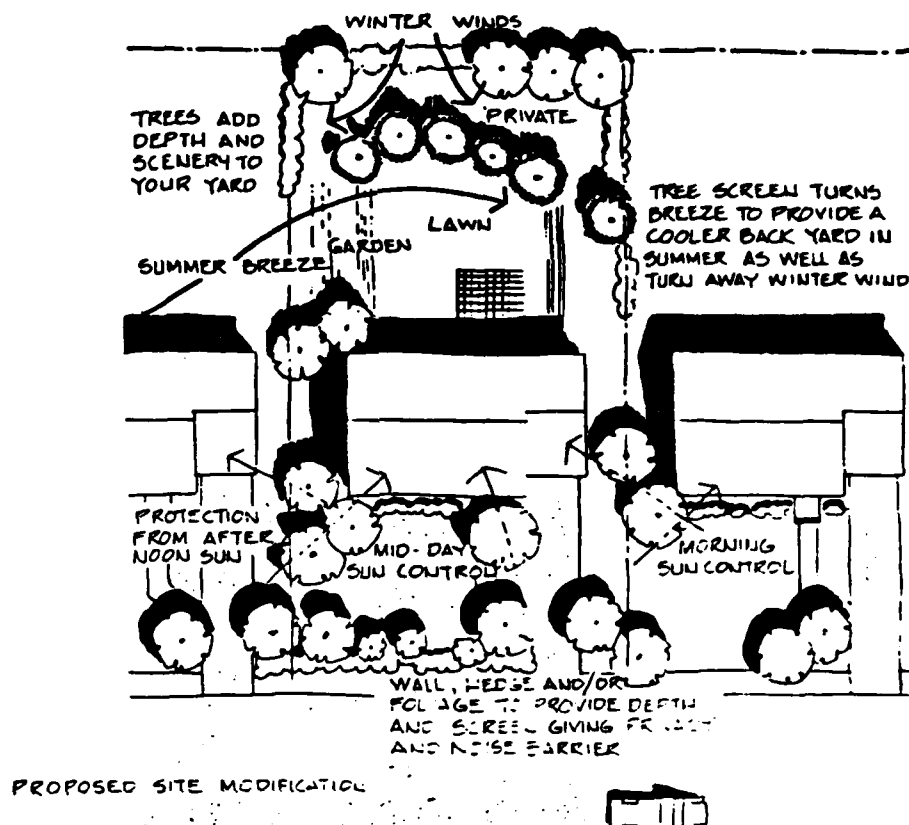


Figure 113: Environmental Influence Illustration (12)

6.4 The Impact of Thermal Mass

One important contributor to the total energy performance of a building is its thermal mass. The SEE technique of energy analysis does not explicitly take the thermal mass of a building's materials into account because of the difficulty of quantifying the exact energy contribution thermal mass gives (2).

Even though the benefits of thermal mass aren't easily derived from formulae, they are real and at times alter energy consumption (Figure 114). EDECT would benefit from an extension which predicts 'ball park' thermal mass contributions to energy design. The determinations would not have to be accurate to the last British Thermal Unit but could rate a design's thermal mass into three or four possi-

ble categories (e.g. poor, medium, good ...) according to material time lag and decrement (35).

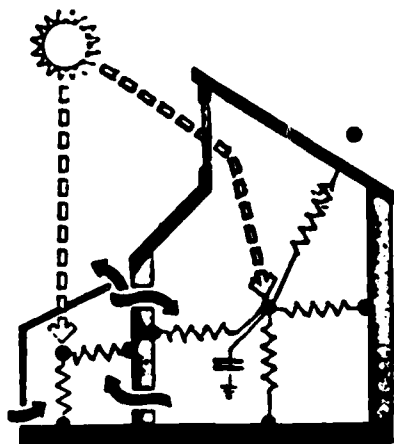


Figure 114: Building Thermal Mass Schematic (35)

6.5 Microcomputer Adaptation

An important extension to EDECT which would give more designers access to it would be to adapt the EDECT code (program) to run on microcomputers. The IBM 4341 computing environment in which EDECT was developed is powerful but few architects or architectural firms have access to such computers. The general trend in computing is towards smaller (in physical size and price) microcomputers with extensive memory capacity.

Microcomputers, such as the IBM AT, have the memory capacity to handle the EDECT program and with the adaptation of the Graphics Subroutine Package (used by the current EDECT code) to the microcomputer graphics environment, EDECT could aid energy design with personal computers as it does now in a minicomputer environment. There would likely be a loss of screen resolution from the 3251 monochrome vector refresh display to whatever microcomputer screen was utilized, but the microcomputer display could also utilize color in EDECT's graphics.

6.6 Energy Economics

The bottom line of the energy concern is cost. Energy consciousness is proportional to the current price per gallon or kilowatt-hour. In economic terms, the real price

of energy includes not only the cost of the source but the life cycle cost of the devices designed to reduce consumption. For example, in an unrestricted energy design environment, an architect may call for several inches of insulation just to get lower resulting heat gain/loss numbers. The fact that the extra insulation may never pay for itself does not enter his/her mind or the calculations. The same holds true for all energy design components.

To properly give the actual cost of energy design decisions, EDECT would have to be extended to determine costs of building components and fuel over the life cycle of a design via economic costing formulae. To be accurate, the base for these equations (current costs, interest rates, etc.) would have to be periodically updated.

6.7 Conclusion

EDECT was never intended to be the energy design system to end all energy design systems. There may never be such a system simply because energy needs and resources in architecture will always change and so must the systems designed to deal with energy in architecture.

However, EDECT was intended to demonstrate that certain weaknesses in other building energy analysis approaches could be overcome. First and foremost, EDECT approaches energy aspects where the greatest impact can be realized; in the schematic design stage. It is not a "cre-pass" analysis either, but rather encourages the designer to make changes through rapid analysis and graphic interaction. Designers are not inarticulate with numbers, but they are trained to communicate graphically, thus EDECT presents complex analyses in a graph (as well as in detailed tables) and enables side by side comparison of different designs and their graphs. EDECT can also help the energy novice grasp basic energy design concepts and speed up and solidify the 'experts' intuitive feel for good energy design. In essence, where most previous approaches do energy analysis, EDECT aids the architect/designer in energy design.

But perhaps the greatest benefit of EDECT was a personal one for its developer. The design and implementation of EDECT was a culmination of theory and practical application in the use of computers as architectural design tools. EDECT is not a total computer aided architectural design system but a subset to an existing modeling system. The lessons learned in adapting EDECT to use ARCHIMODOS data and then to go on to further refine design aspects of a model were invaluable. Lessons learned earlier in theory on graphic interaction, data structures, programming finesse, etc. became real as

they had to be pragmatically applied to make EDECT work. For me, the EDECT experience and the academic program from which it comes has been priceless.

APPENDIX A. Sample Extended Numerical Analysis

This following sample is a printout of extended numerical energy analysis results that were written to file when I was picked as the response to strip message no. 26. The analysis is for object 2 in the example from Chapter 3.

The header to each tabulation gives the dump number (the first dump of a session is always 1), BLT (building type), MAC (macroclimate), HTT (heating system), TLT (lighting system), OCCUP (number of occupants), area, and PLF (perimeter linear feet) of the current object at time of analysis.

***** DUMP # 1 *****

BLT,MAC,HTT,TLT,OCCUP: 6. 8. 2. 1. 5.
 AREA OF OBJECT 2 IS: 1584.25 SQ. FT.
 PLF OF OBJECT 2 IS: 194.00 LIN. FT.

 ----- HEAT LOSS (BTU/F*HR) -----

ROOF HEAT LOSS: 475.

OPENING / WALL: 25	AREA: 70.67	U-VAL: 0.60	HEAT LOSS: 42.
OPENING / WALL: 26	AREA: 72.89	U-VAL: 0.60	HEAT LOSS: 44.
OPENING / WALL: 26	AREA: 104.44	U-VAL: 0.60	HEAT LOSS: 63.
OPENING / WALL: 26	AREA: 78.75	U-VAL: 0.60	HEAT LOSS: 47.
OPENING / WALL: 27	AREA: 81.28	U-VAL: 0.60	HEAT LOSS: 49.
OPENING / WALL: 28	AREA: 88.88	U-VAL: 0.60	HEAT LOSS: 53.
OPENING / WALL: 29	AREA: 46.22	U-VAL: 0.60	HEAT LOSS: 28.
OPENING / WALL: 29	AREA: 6.67	U-VAL: 0.60	HEAT LOSS: 4.
OPENING / WALL: 29	AREA: 45.78	U-VAL: 0.60	HEAT LOSS: 27.
OPENING / WALL: 29	AREA: 6.22	U-VAL: 0.60	HEAT LOSS: 4.
OPENING / WALL: 30	AREA: 34.37	U-VAL: 0.30	HEAT LOSS: 10.
OPENING / WALL: 30	AREA: 6.46	U-VAL: 0.60	HEAT LOSS: 4.
OPENING / WALL: 30	AREA: 7.67	U-VAL: 0.60	HEAT LOSS: 5.
OPENING / WALL: 30	AREA: 11.56	U-VAL: 0.60	HEAT LOSS: 7.
OPENING / WALL: 31	AREA: 46.22	U-VAL: 0.60	HEAT LOSS: 28.
OPENING / WALL: 31	AREA: 46.75	U-VAL: 0.60	HEAT LOSS: 28.
OPENING / WALL: 31	AREA: 6.03	U-VAL: 0.60	HEAT LOSS: 4.
OPENING / WALL: 31	AREA: 6.88	U-VAL: 0.60	HEAT LOSS: 4.
OPENING / WALL: 32	AREA: 64.00	U-VAL: 0.60	HEAT LOSS: 38.
TOTAL OPENING HEAT LOSS:			489.

WALL 25/	AREA: 358.08	U-VAL: 0.12	HEAT GAIN: 963.
WALL 26/	AREA: 592.67	U-VAL: 0.12	HEAT GAIN: 1593.
WALL 27/	AREA: 347.47	U-VAL: 0.12	HEAT GAIN: 934.
WALL 28/	AREA: 191.12	U-VAL: 0.12	HEAT GAIN: 514.
WALL 29/	AREA: 315.11	U-VAL: 0.12	HEAT GAIN: 847.
WALL 30/	AREA: 228.70	U-VAL: 0.12	HEAT GAIN: 615.
WALL 31/	AREA: 314.12	U-VAL: 0.12	HEAT GAIN: 844.
WALL 32/	AREA: 216.00	U-VAL: 0.12	HEAT GAIN: 581.

TOTAL WALL HEAT GAIN: 6890.

TOTAL AVG. SOL-AIR GAIN (100% SUN): 37202.
 AVERAGE WINTER SOL-AIR GAIN: 19717.
 AVERAGE SUMMER SOL-AIR GAIN: 27901.

----- ENVELOPE HEAT GAIN (BTU/F*HR) -----

ROOF HEAT GAIN: 119.
 WALL HEAT GAIN: 77.
 TOTAL OPENING HEAT GAIN: 489.
 INFILTRATION HEAT GAIN: 637.

TOTAL HEAT GAIN THROUGH BUILDING ENVELOPE: 1322.

VENTILATION HEAT GAIN: 81.

SENSIBLE OCCUPANT HEAT GAIN: 1250.
 LATENT OCCUPANT HEAT GAIN: 1000.

LIGHTING HEAT GAIN: 17624.
 EQUIPMENT HEAT GAIN: 2693.

WINTER BUILDING OPERATION HEAT GAIN: 21568.
 SUMMER BUILDING OPERATION HEAT GAIN: 22568.

WINTER INTERNAL HEAT GAIN: 41285.
 SUMMER INTERNAL HEAT GAIN: 50469.

----- HEATING LOAD -----

OCCUPIED HEATING DEGREE HOURS (F*HR): 22051.
 OCCUPIED ENVELOPE HEATING LOAD (BTU): 44448832.
 OCCUPIED VENTILATION HEATING LOAD (BTU): 1786162.
 TOTAL OCCUPIED HEATING LOAD (BTU): 46234992.

UNOCCUPIED DEGREE HOURS (F*HR): 1813.
 UNOCCUPIED ENVELOPE HEATING LOAD (BTU): 3654953.
 TOTAL UNOCCUPIED HEATING LOAD (BTU): 3654853.

TOTAL BUILDING HEATING LOAD (BTU): 49885840.
 TOTAL HEATING ENERGY USE (BTU): 71271200.

=====

COOLING LOAD

=====

TOTAL OCCUPIED COOLING HOURS (HRS.):	5520.
OCCUPIED COOLING DEGREE HOURS (F*HR):	4892.
OCCUPIED SOL-AIR COOLING LOAD (BTU):	154027424.
OCCUPIED CONDUCTION COOLING GLASS (BTU):	2391045.
SENSIBLE + LATENT VENT. COOLING LOAD (BTU):	447156.
OCCUPIED COOLING LOAD (BTU):	12471010.
LIGHTING COOLING LOAD (BTU):	97294896.
PROCESS + EQUIPMENT COOLING LOAD (BTU):	14867809.

TOTAL OCCUPIED COOLING LOAD (BTU):	166055024.
TOTAL COOLING ENERGY USE (BTU):	415137536.

=====

ENERGY USE SUMMARY

=====

DOMESTIC HOT WATER FUEL USE (BTU):	62474976.
------------------------------------	-----------

ANNUAL LIGHTING LOAD (BTU):	22114800.
ANNUAL EQUIPMENT LOAD (BTU):	160697376.

TOTAL CONNECTED ELECTRICAL LOAD (BTU):	182812176.
----------------------------------------	------------

=====

ANNUAL ENERGY USE

=====

TOTAL HEATING ENERGY USE (BTU):	71271200.
TOTAL COOLING ENERGY USE (BTU):	415137536.
DOMESTIC HOT WATER FUEL USE (BTU):	62474976.
TOTAL CONNECTED ELECTRICAL LOAD (BTU):	182812176.
TOTAL ANNUAL ENERGY USE (BTU):	731695616.

APPENDIX B. Error and Strip Messages

Following is a complete list of the error and strip messages EDECT issues in the Strip Message Box. Error messages with explanations are presented first.

B.1 EDECT Error Messages

- # 1) **ERROR. MEMORY ALREADY CONTAINS OBJECTS. COMMAND IGNORED.

explanation: Objects can be read from disk memory only once. Any attempt to READ FROM DISK more than once during a session will in this message.

- # 2) **ERROR: THERE ARE NO OBJECTS TO SAVE TO DISK.

explanation: If there are no objects in session memory and the command SAVE TO DISK is picked, this error message will be issued.

- # 3) **ERROR. QUADRANT ALREADY CONTAINS IMAGE. SAVE OR CLEAR QUADRANT.

explanation: When in the orientation mode and the user attempts to bring up a footprint in a quadrant already containing a footprint, this message is issued.

- # 4) **ERROR. THERE IS NO ACTIVE QUADRANT.

explanation: If in the orientation mode the user attempts to bring up a footprint image by picking (RE)ORIENT without having picked an active

quadrant first, this message will be issued.

5) **ERROR. ALL QUADRANTS ARE EMPTY.

explanation: If the user picks the command SAME SAVE or NEW SAVE during (re)orientation and all quadrants are empty, this error message will result.

6) **ERROR. DISPLAY(S) EMPTY.

explanation: When (re)defining windows/doors the user may transfer temporary changes stored in one of two windows to the current object. If the window picked for transfer is blank, this message will be issued.

7) NO OBJECT HAS BEEN SELECTED.

explanation: If any primary command in (RE)DEFINE, ANALYZE, or IMPROVEMENTS categories is picked and no current object has been selected, this message will be given.

B.2 EJECT Strip Messages

Note: Any text appearing below in parenthesis is light pen activated.

1) PICK OBJECT FROM OBJECT LIST OR (RETURN).

2) DELETE OBJECT FROM OBJECT LIST OR (RETURN).

- # 3) PICK NAME FROM AVAILABLE NAMES LIST OR (RETURN).
- # 4) SELECT QUADRANT TO DISPLAY IN OR "MAIN MENU" TO RETURN.
- # 5) PICK DEGREES OR (RETURN).
- # 6) CURRENT OBJECT WILL BE WRITTEN OVER. CONTINUE?
(Y) (N) -
- # 7) SELECT QUADRANT NUMBER ORIENTATION TO BE SAVED.
- # 8) ALL DISK NAMES WILL BE WRITTEN OVER. CONTINUE?
(Y) (N) -
- # 9) PICK WALL FROM ENLARGED FOOTPRINT OR "MAIN MENU" TO RETURN.
- # 10) SELECT OPENING->OPERATION, (RETURN), OR SAVE IN WINDOW (1) (2).
- # 11) OPENING MUST BE SELECTED BEFORE OPERATION. YOU MAY ALSO (RETURN).
- # 12) PERMANENT OPENINGS WILL BE CHANGED!! CONTINUE?
(Y) (N) -
- # 13) ILLEGAL OPENING/CONDITION EXISTS. FRUSTRATED? YOU MAY (RETURN).

- # 14) PICK OPENING->TYPE. TO EXIT YOU MAY (RETURN).
- # 15) PICK OPENING->TYPE. ALL (DEFINED) / (UNDEFINED) OPENINGS SAME? TO EXIT: (RETURN).
- # 16) SELECT MACROCLIMATE NUMBER FROM MAP. TO REGISTER SELECTION: (RETURN).
- # 17) PICK SELECTIONS. TO REGISTER SELECTIONS: (RETURN).
- # 18) TO ADD OVERHANG, PICK WALL BOTTOM. ELSE PICK OVERHANG -> OPERATION.
- # 19) PERMANENT OVERHANGS WILL CHANGE!!! CONTINUE? (Y) (N).
- # 20) PICK ROOF CONSTRUCTION TYPE NUMBER, OR (RETURN).
- # 21) CURRENT ROOF THICKNESS IS LESS THAN CONSTRUCTION SELECTED. MODIFY? (Y) (N).
- # 22) PICK WALL CONSTRUCTION TYPE -> WALL SEGMENT OF MENU COMMAND.
- # 23) CURRENT WALL THICKNESS IS LESS THAN CONSTRUCTION SELECTED. MODIFY? (Y) (N).
- # 24) YOU MAY REQUEST ADDITIONAL (EXPLANATION) OR (RETURN).

25) (RETURN)

26) DO YOU WISH TO SAVE THE ANALYSIS TO DISK? (Y) (N).

APPENDIX C. Running EDECT

This appendix explains how to run EDECT at The Ohio State University CAAED Lab.

C.1 Logon to CHS

The first step is to log on to the system. From a 3279 terminal the user types in

```
LOGON <userid> <password>
```

and presses the ENTER key. Provided that the correct password is given, the user is now logged on to the system.

C.2 The EXEC Program and Data Disk Files

Before the user can begin, there must be a copy of the EXEC program which runs EDECT in his file directory. If there is not, the user can copy it from the ARCH14 account. To do this, the user does the following.

1. Link to the ARCH14 account by typing in the following two commands, followed by the ENTER key:

```
LINK ARCH14 191 291 BR
```

```
ACCESS 291 B
```

2. Copy the EXEC program from the B disk to the user disk:

```
COPY ENRUN EXEC B = = A
```

3. Detach from ARCH14:

RELEASE B (DETACH

Before invoking the ENRUN EXEC program, the user should be aware of the data disk files, which are used to read data in and save the data generated during the session onto his disk. These files are defined in the EXEC program through the FILEDEF statements (Figure 115). The WEATHR1 and WEATHR2 data files are read only and contain tabularized information used by EDECT in running energy heat gain/loss calculations. The SAVEAN data file is write only and is where any extended energy analyses reside if dumped to disk by the user during a session.

The other five data files are read/write and with the exception of DATA3D, may or may not contain data at the end of a session. They are all object description files and unless a user has defined all aspects of an object with EDECT then saved those definitions to disk, there may be no information contained within. When an object(s) first comes over from ARCHIMODCS, the only data file with data is DATA3D, which contains the object 3D data structures filled by ARCHIMODCS and used by EDECT. OPENGs contains the EDECT opening data structures; OVRHNGS the overhang data; BLDSYS the data for the building systems (occupants, lighting, etc.); and WALROOF the data structures describing wall and roof construction of EDECT objects.

```
FILEDEF 11 DISK DATA3D DATA A (RECFM FBA LRECL 80)
FILEDEF 13 DISK WEATHR1 DATA A (RECFM FBA LRECL 80)
FILEDEF 14 DISK WEATHR2 DATA A (RECFM FBA LRECL 80)
FILEDEF 17 DISK OPENGs DATA A (RECFM FBA LRECL 80)
FILEDEF 18 DISK OVRHNGS DATA A (RECFM FBA LRECL 80)
FILEDEF 19 DISK BLDSYS DATA A (RECFM FBA LRECL 80)
FILEDEF 20 DISK WALROOF DATA A (RECFM FBA LRECL 80)
FILEDEF 22 DISK SAVEAN DATA A (RECFM FBA LRECL 80)
```

Figure 115: Data disk file definitions

C.3 Running the Program

The user is now ready to run the program. This is done by typing:

ENRUM

The user is prompted for the device address of the 3251 terminal, which is located in the upper right corner of the terminal. The user types this number on the 3279. The user now waits until the program is loaded. When this is done, the initial EDECT screen menu appears on the 3251 and the system awaits the first command.

BIBLIOGRAPHICAL REFERENCES

- (1) Ackerman, A. "Computers: Energy Modeling". Progressive Architecture. Stamford: Reinhold Publishing, December 1985.
- (2) American Institute of Architects. Energy in Design Techniques. The AIA Energy Professional Development Program. Washington: The AIA, 1981.
- (3) ASHRAE Handbook of Fundamentals. New York: American Society of Heating, Refrigeration and Air Conditioning Engineers, 1978.
- (4) ASHRAE Task Group on Energy Requirements for Heating and Cooling of Buildings. Procedure for Determining Heating and Cooling Loads for Computerizing Energy Calculations. New York: American Society of Heating, Refrigeration, and Air Conditioning Engineers, 1976.
- (5) Anderson, E. Solar Energy: Fundamentals in Building Design. New York: McGraw-Hill Book Company, 1977.
- (6) Anderson, E. "An Architect's Energy Program Using Interactive Graphics". Computer Graphics, Vol. 2, No. 8. San Francisco: Cygnus Publications, September 1979.
- (7) Automated Procedures for Engineering Consultants. Energy Simulation Program II. Dayton: Automated Procedures for Engineering Consultants, 1981.
- (8) Arizona State University. Solar-Oriented Architecture. AIA Research Corporation, 1975.
- (9) Braden III, S. Graphic Standards of Solar Energy. Boston: CBI Publishing Company, Inc., 1977.
- (10) Broadbent, G. Design in Architecture. New York: John Wiley & Sons, 1973.
- (11) Clark, W. Energy for Survival. New York: Anchor Books, 1974.

(12) Crowther, R. L. Sun Earth. New York: Charles Scribner's Sons, 1977.

(13) Forsyth, R. Expert Systems. London: Chapman and Hall, 1984.

(14) Hayes-Roth, F. et. al. Building Expert Systems. Reading: Addison-Wesley, 1983.

(15) Highlander, D. A. CEED, A Computer-Aided Energy Efficient Design Program. Master's Thesis, Graduate CAAC Program, Department of Architecture, The Ohio State University, 1982.

(16) Hittle, D. C. The Building Loads Analysis System (BLAST) Program. Version 2.0 User's Manual. Champaign: U.S. Army Construction Engineering Research Laboratory, Army Report CERL-TR-E-153, 1979.

(17) Horak, H. L. et. al. DOF-2 Reference Manual. Los Alamos: Los Alamos Scientific Laboratory, 1979.

(18) Horvitz, E.; Sahni, C. Fundamentals of Data Structures. Potomac: Computer Science, Inc., 1976

(19) Jennings, B. H. Environmental Engineering, Analysis and Practice. New York: Harper & Row, 1970.

(20) Kellog, R. E. "CAD-Spreadsheet linkages for Design and Analysis". ACADIA Workshop '85 Proceedings. Department of Architecture, Arizona State University, 1985.

(21) Markus, T. A. "The Real Cost of a Window". Building and Environment. Vol. 8. New York: 1969.

(22) Mazria, E. The Passive Solar Energy Book. Emmaus: Rodale Press. 1979.

(23) McGuinness, W. J.; Stein, B. Mechanical and Electrical Equipment for Buildings. New York: John Wiley & Sons, 1978.

(24) McKetta, J. J. Why the U.S. Will Not Achieve Energy Self Sufficiency. Speed Scientific School, The University of Louisville, 1979.

(25) Milne, M.; Yoshikawa, S. "SOLAR-5, An Interactive Computer-Aided Passive Solar Building Design System". Computer Graphics, Vol. 2, No. 8. San Francisco: Cygnus Publications, September 1979.

(26) Mitchell, W.J. Computer-Aided Architectural Design. New York: Van Nostrand Reinhold Company, 1977.

(27) Olgyay, V. Design with Climate. Princeton: Princeton University Press, 1963.

(28) Patton, A. R. Solar Energy for Heating and Cooling of Buildings. Park Ridge: Noyes Data Corporation, 1975.

(29) Paul, J. K. Solar Energy Design and Materials. Park Ridge: Noyes Data Corporation, 1977.

(30) Pittman, J. B. An Interactive Graphics Environment for Architectural Energy Simulation. Master of Science Thesis, Cornell University, 1982.

(31) Quadrel, R. W.; Chassin, D. P. "Energy Graphics". ACADIA Workshop '85 Proceedings. School of Architecture, Arizona State University, 1985.

(32) Radford, A. D. "Optimization, Simulation and Multiple Criteria in Window Design". Computer Aided Design, Vol. 13, No. 6. London: November 1981.

(33) Radford, A. D.; Gero, J. S. "On the Design of Windows". Environment and Planning Bulletin, Vol. 6, No. 1. New York: 1979.

(34) Schank, R. C. The Cognitive Computer. Reading: Addison-Wesley, 1984.

(35) Software by BSG. CALPAS3 and CALPAS4. Berkeley: Basic Software Group, 1985.

(36) U.S. Department of Commerce. Predesign Energy Analysis - A New Graphic Approach to Energy Conscious Design for Buildings. Springfield: National Technical Information Service, 1980.

(37) U.S. Department of Energy. Passive Solar Design Handbook. Washington: U.S. Government Printing Office, 1982.

(38) Ward, D. S. How to Solve Materials and Design Problems in Solar Heating and Cooling. Park Ridge: Noyes Data Corporation, 1982.

(39) Watson, D.; Labs, K. Climatic Design. New York: McGraw-Hill Book Company, 1983.

(40) Yessios, C. I. et. al. Archimedes User's Manual. CAAED Lab, Department of Architecture, The Ohio State University, 1984.

(41) Zarke, J. "Computer Applications in the Design of Energy Conscious Buildings". Computer Aided Design, Vol. 14, No. 1. London: January 1982.

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